PHASE I
WATERSHED ASSESSMENT FINAL REPORT
AND TMDL

CENTRAL BIG SIOUX RIVER
BROOKINGS, LAKE, MOODY, AND MINNEHAHA COUNTIES
SOUTH DAKOTA

South Dakota Watershed Protection Program
Division of Financial and Technical Assistance
South Dakota Department of Environment and Natural Resources
Steven M. Pirner, Secretary

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Project Sponsor and Prepared By

East Dakota Water Development District

State of South Dakota
Mike Rounds, Governor

March 2004

This project was conducted in cooperation with the State of South Dakota and the United States Environmental Protection Agency, Region 8.

EPA Grant # C9998185-99

EXECUTIVE SUMMARY

PROJECT TITLE: Central Big Sioux River Watershed Assessment

START DATE: May 01, 1999	**COMPLETION DATE:** 09/30/04
FUNDING:	**TOTAL BUDGET:** $623,634 (projected)
TOTAL EPA GRANT:	$371,620
TOTAL EXPENDITURES OF EPA FUNDS:	$361,265.79 (through 12/31/04)
TOTAL SECTION 319 MATCH ACCRUED:	$286,755.12 (through 12/31/04)
BUDGET REVISIONS:	None
TOTAL EXPENDITURES:	$648,020.91 (through 12/31/04)

SUMMARY ACCOMPLISHMENTS

The Central Big Sioux River watershed assessment project began in April of 1999 and lasted through December of 2003 when data analysis and compilation into a final report was completed. The assessment was conducted as a result of being placed on the 1998 303(d) list for fecal coliform bacteria, and total suspended solids (TSS) problems. The project met all of its milestones in a timely manner, with the exception of completing the final report. This was delayed while completion of an additional watershed (North Central Big Sioux River Watershed Assessment, South Dakota), that was funded under the same grant, was completed.

An EPA section 319 grant provided a majority of the funding for this project. The Department of Environment and Natural Resources and East Dakota Water Development District provided matching funds for the project.

Water quality monitoring and watershed modeling resulted in the identification of several sources of impairment. These sources may be addressed through best management practices (BMPs) and the construction of several waste management systems at animal feeding operations.

The long term goal for this project was to locate and document sources of non-point source pollution in the Big Sioux River (BSR) watershed and provide feasible restoration alternatives to improve water quality problems within the watershed. Through identification of sources of impairment in the watershed, this goal was accomplished.

In addition, SD DENR and EDWDD have initiated contact with MPCA concerning pollution reduction efforts for those tributaries, targeted for TMDLs in South Dakota, which drain Minnesota land.

ACKNOWLEDGEMENTS

The cooperation of the following organizations and individuals is gratefully appreciated. The assessment of the Central Big Sioux River and its watershed could not have been completed without the cooperation of the landowners in the study area - their cooperation is greatly appreciated.

Brookings County Conservation District
EcoAnalyst, Inc
Lake County Conservation District
Minnehaha County Conservation District
Moody County Conservation District
Natural Resource Solutions
Sioux Falls Health Lab
South Dakota Cattlemen's Association
South Dakota Corn Growers Association
South Dakota Department of Environment and Natural Resources
South Dakota Department of Game, Fish and Parks
South Dakota Soybean Association
South Dakota State University, Department of Wildlife and Fisheries, GAP Analysis Lab
South Dakota State University, Water Resource Institute
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United States Department of Agriculture, Natural Resource Conservation Service
United States Fish and Wildlife Service
United States Geological Survey

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABBREVIATIONS

AFOs	Animal Feeding Operations – *facility where animals are confined, fed, or maintained for a total of 45 days in any 12 month period, and where vegetation is not sustained in the normal growing season over any portion of the lot or facility*
AGNPS	Agricultural Non-Point Source – *an event-based, watershed-scale model developed to simulate runoff, sediment, chemical oxygen demand, and nutrient transport in surface runoff from ungaged agricultural watersheds*
BMP	Best Management Practice – *an agricultural practice that has been determined to be an effective, practical means of preventing or reducing nonpoint source pollution*
BSR	Big Sioux River
CFU	Colony Forming Units
CV	Coefficient of Variance – *a statistical term used to describe the amount of variation within a set of measurements for a particular test*
DC	District Conservationist
DO	Dissolved Oxygen
EDWDD	East Dakota Water Development District
HEP	High Erosion Potential
IBI	Index of Biological Integrity
IPI	Index of Physical Integrity
LEP	Low Erosion Potential
MOS	Margin of Safety – *an index indicating the amount beyond the minimum necessary*
NGP	Northern Glaciated Plains
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units – *measure of the concentration of size of suspended particles (cloudiness) based on the scattering of light transmitted or reflected by the medium*
SD	South Dakota
SDDENR	South Dakota Department of Environment and Natural Resources
SDGFP	South Dakota Department of Game Fish & Parks
SDM	Sediment Delivery Model
SDSU	South Dakota State University
su	Standard Units
TBD	To Be Determined
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load – *a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of the amount to the pollutant's sources*
TSS	Total Suspended Solids
umhos/cm	micromhos/centimeter – *unit of measurement for conductivity*
USFWS	United States Fish and Wildlife Service

USGS	United States Geologic Survey
WCBP	Western Corn Belt Plains
WQ	Water Quality – *term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose*
WRI	Water Resource Institute

INTRODUCTION

PURPOSE

The purpose of this assessment is to determine the sources of impairment and develop restoration alternatives for the central portion of the Big Sioux River (BSR) (between the communities of Volga and Sioux Falls) and major tributaries in Brookings, Lake, Moody and Minnehaha counties of South Dakota.

Direct runoffs to the river, as well as permanent and intermittent tributaries, contribute loadings of sediment, nutrients, and fecal coliform bacteria primarily related to seasonal snow melt or rainfall events. In the 2006 and previous Waterbody Lists and 305(b) Assessments, (SDDENR 2006), the central portion of the Big Sioux River, as targeted in this project, has various segments listed as only partially supporting or not supporting the designated uses (see Table 1). Total suspended solids (TSS) are the primary problem in the northern portion of this segment, between the communities of Brookings and Dell Rapids. From Dell Rapids to Brandon, and including the City of Sioux Falls, excessive fecal coliform bacteria and total suspended solids are the major problems. Table 2 shows those locations and their assessment unit IDs that have been identified as not meeting their water quality criteria (SDDENR 2006). Through water quality monitoring (chemical and biological), stream gaging, and land use analysis, sources of impairment can be determined and feasible alternatives for restoration efforts can be developed.

The 2006 South Dakota 303(d) Waterbody List identifies this portion of the river as a priority for the development of Total Maximum Daily Loads (TMDL's) of the pollutants of concern. This final TMDL assessment report will serve as the foundation for restoration projects that can be developed and implemented to meet the designated uses and water quality standards of the central BSR and its tributaries. This project is intended to be the initial phase of a series of watershed-wide restoration implementation projects.

Table 1. Beneficial Uses and the WQ Standards

Designated Beneficial Use	Numeric Standard for Fecal Coliform bacteria	Numeric Standard for Total Suspended Solids
Domestic Water Supply	*	*
Warmwater Permanent Fish Life Propagation	*	$\leq 90^1/158^2$
Warmwater Semi-Permanent Fish Life Propagation	*	$\leq 90^1/158^2$
Warmwater Marginal Fish Life Propagation	*	$\leq 150^1/263^2$
Immersion Recreation	≤ 200 mean sample ≤ 400 single sample	*
Limited Contact Recreation	≤ 1000 mean sample ≤ 2000 single sample	*
Wildlife Propagation and Stock Watering	*	*

1. 30-day average 2. Daily maximum
* no fecal coliform and/or TSS standards established for this designated beneficial use

Table 2. 2006 303(d) Listing of Locations and Assessment Unit IDs Not Meeting Water Quality Criteria

Segment	Assessment Unit ID	Coinciding EDWDD Sites	Basis	Cause	Source
Brookings to I-29	SD-BS-R-Big_Sioux_06	T01-T09 T10 R01-R04	DENR460702	Suspended Solids	Crop Production, Non-Irrigated Crop Production, Grazing in Riparian Zones, Managed Pasture Grazing, and Livestock
I-29 to Near Dell Rapids	SD-BS-R-Big_Sioux_07	R04-R08 T11-T14	DENR46BS18	Suspended Solids	Crop Production and Livestock
Near Dell Rapids to Below Baltic	SD-BS-R-Big_Sioux_08	R08	DENR460703	Pathogens	Livestock
Below Baltic to Skunk Creek	SD-BS-R-Big_Sioux_09	R08-R10 T15-T23	DENR46BS23	Pathogens	Livestock
Skunk Creek to Diversion Return	SD-BS-R-Big_Sioux_010	R10 R11	DENR460664	Pathogens	Residential Districts
Diversion Return to SF WWTF	SD-BS-R-Big_Sioux_011	R11 T25	DENR46BS29	Pathogens Suspended Solids	Municipal (Urbanized Area), Streambank Modifications/Destabilization, and Hydrostructure Flow Modification

GENERAL WATERSHED DESCRIPTION

The central BSR watershed is approximately 1,282,560 acres (519,255 hectares) in size and lies within the Big Sioux Basin (Figure 1). The BSR is a permanent, natural river that flows north to south along the eastern edge of South Dakota and drains into the Missouri River at Sioux City, Iowa. There are also numerous intermittent tributaries, which only carry water during spring snowmelt or rainfall events. The segment of the central BSR watershed for this project extends from the BSR confluence with North Deer Creeks (near Volga) south to County Road 38 south east of Sioux Falls. Within the study area, the Big Sioux River rarely becomes intermittent; however, wet-dry cycles have prominent effects on annual discharge. Tributaries often become intermittent during dry phases.

The river and tributaries drain much of Brookings, Lake, Moody, and Minnehaha Counties, as well as a portion of southwestern Minnesota. The river also receives storm sewer discharges or otherwise enhanced runoff from several communities along its course, including the cities of Brookings, Flandreau, Dell Rapids, Sioux Falls, and Brandon. The City of Sioux Falls utilizes the BSR as the source for approximately fifty percent of their drinking water. The river and tributaries also recharge shallow aquifers found adjacent to these water bodies. These shallow aquifers are the principle source of drinking water for the residents of the region. Several sections of the BSR have been channelized (straightened and/or artificially stabilized) and there are numerous road crossings of the river and tributaries.

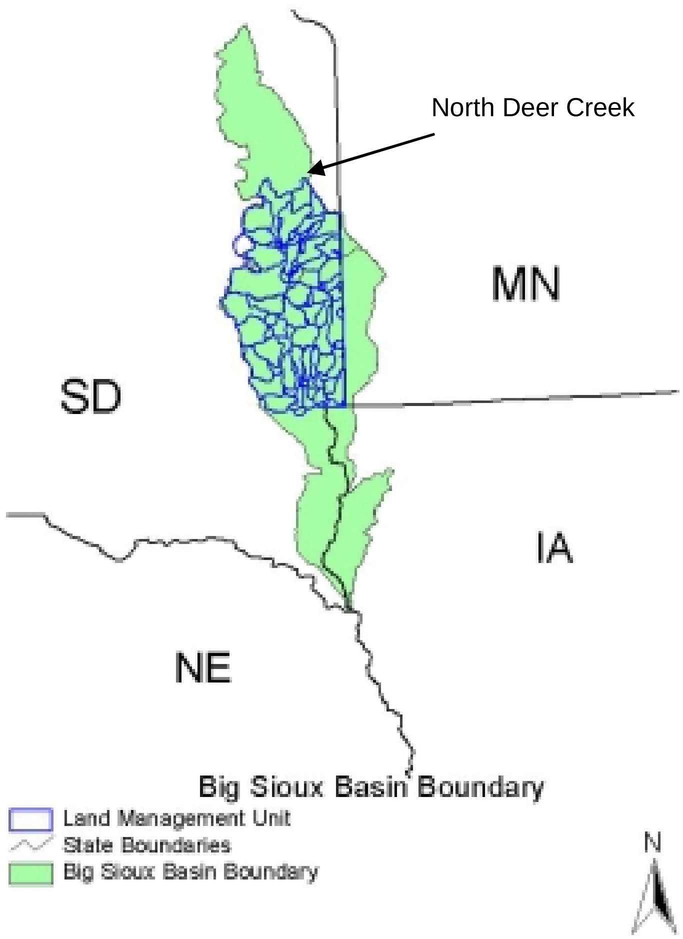


Figure 1. The Big Sioux Basin Boundary and Location of the CBSRW

Geology and Soils

Based on the relative age of the landscape, the surficial character of the watershed can be divided into two parts. Along the valley of the BSR and the eastern tributaries, drainage is well developed and un-drained depressions are rare. To the west of the river, drainage is poor, and there are many potholes, sloughs, and lakes. The relief in the area is moderate. Land elevation ranges from nearly 2,000 feet above mean sea level in the northeastern part of the study area to about 1,265 feet in the southern edge of the project area.

The bedrock in the basin is the Precambrian Sioux Quartzite which is exposed in the river valley at Sioux Falls and several other places in the central part of the basin. Cretaceous period formations which overlie the quartzite include Dakota Sandstone, Granerous Shale, Greenhorn Limestone, Carlile Shale, Niobrara Chalk, and Pierre Shale.

The Cretaceous formations are covered by glacial drift which is physically divided into till, outwash, and glacial lake deposits. The glacial till is the predominant drift and it consists of a heterogeneous mixture of silt, sand, and large rock fragments in a matrix of clay. The outwash is commonly found in the valleys and plains of the basin and consists of gravel, sand, and silt. It ranges in thickness from a few feet to almost 200 feet. Glacial lake sediments occur in small depressions in the till areas. They are usually clay and silt and vary from 4 to 10 feet in thickness.

Recent alluvial deposits of clay, silt, and sand with some gravel occur along both sides of the BSR and its tributaries and are usually 3 to 15 feet in thickness.

Soils within the watershed area are derived from a variety of parent materials. Upland soils are relatively fine-grained, and have developed over glacial till or eolian (loess) deposits. Coarse-grained soils are found along present or former water courses, and are derived from glacial outwash or alluvial sediments. A significant shift to highly erodeable soils occurs near the area of Dell Rapids.

Climate

The average annual precipitation in the central BSR watershed is 23.2 inches, of which 76 percent typically falls during the growing season of April through September (See Figures 2 and 3). Tornadoes and severe thunderstorms strike occasionally. These storms are often of only local extent and duration, and occasionally produce heavy rainfall events. The average seasonal snowfall is 36.5 inches per year (SDSU 2003).

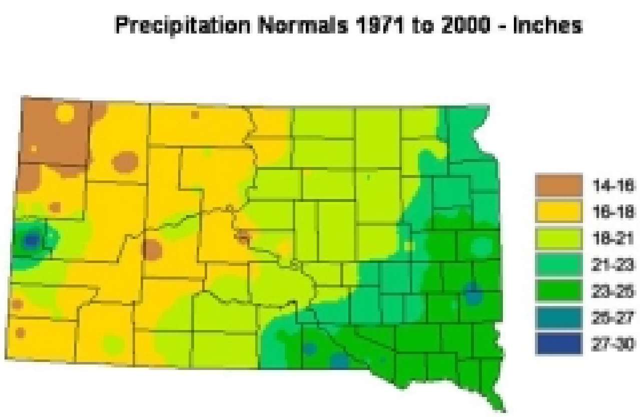


Figure 2. South Dakota Precipitation Normals in Inches from 1971 to 2000

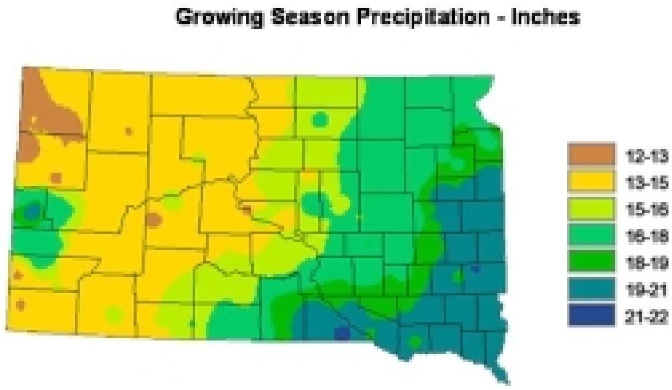


Figure 3. South Dakota Growing Season Precipitation in Inches from
1971 to 2000

Land Use

Land use in the watershed is predominantly agricultural (Figure 4). Approximately 63 percent of the area is cropland, such as corn and soybeans, and 32 percent is grassland and pastureland. Numerous animal feeding operations are located in the watershed, of which 827 were visited and evaluated. More than 153,000 animals were documented. Of this number, 77 percent were cattle, 11 percent each for pigs and sheep, and the remaining one percent of the livestock included chickens, horses, and buffalo. Significant urban development and growth has taken place in and around the communities of Brookings, Flandreau, Dell Rapids, Sioux Falls and Brandon.

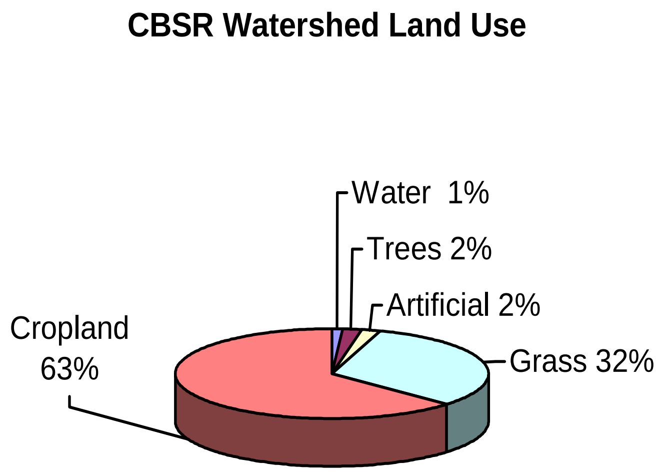


Figure 4. Landuse in the CBSRW

Population

A majority of the population in the Central Big Sioux River study area lives within Minnehaha County. The largest city in the state of South Dakota, Sioux Falls, lies within this county. Other towns in Minnehaha County include Dell Rapids, Garretson, Colton, Hartford, and Brandon. Brookings County has the next largest population in the study area, which includes the towns of Brookings, Elkton, and Aurora. Other towns in the study area include Chester in Lake County and in Moody County, the towns of Flandreau, Colman, Egan, and Trent. Table 3 shows the land area of each county, the people per square mile, and the population based on the 2000 Census.

Table 3. Land Area and Population of Brookings, Lake, Moody, and Minnehaha Counties

	Brookings	Lake	Moody	Minnehaha	South Dakota
Land Area (sq. mi)	794	563	520	810	75,885
People (sq. mi)	35.5	20	12.7	183.1	9.9
Population (2000)	28220	11276	6595	148281	754,844

History

The Big Sioux River, like most rivers across the Midwest, has a watershed that has been converted from a range of tallgrass prairie and deciduous hardwoods to a matrix of intensive agricultural uses with areas of urban/residential sprawl. This conversion has resulted in large-scale alterations to watershed level processes. Primarily, the alteration has been an increase in overland flow of energy and material resources resulting from a decrease in ground-water infiltration/subsurface recharge. An increase in surface runoff has been associated with increases in the non-point source transport of sediment, nutrient, agricultural and residential chemicals, and feedlot runoff.

In the central Big Sioux River watershed, evidence has shown that increases in surface water runoff (mean annual discharge near Dell Rapids) have occurred as a likely response to agricultural land uses. This increase in runoff or altered hydrology may be partially responsible for high levels of total suspended solids and may be associated with other impairments to the central Big Sioux River watershed caused by non-point sources of pollution.

PROJECT DESCRIPTION

The boundaries of the central Big Sioux River watershed in eastern South Dakota study area were defined by the boundaries of tributaries that enter the Big Sioux River between highway 14 near Volga and Brookings, to highway 38 east of Sioux Falls. This 1,282,560 acre area lies within two ecoregions (Level III): Northern Glaciated Plains (NGP) and Western Corn Belt Plains (WCBP). Within the NGP, two of 15 level IV ecoregions are represented in the assessment area: Big Sioux Basin and Prairie Coteau. Within the WCBP, one of two level IV ecoregions is represented in the assessment area: Loess Prairies (Figure 5). Descriptions of the three Level IV ecoregions are provided in Table 4. Monitoring sites were dispersed among 33 tributary locations and 13 river locations throughout the study area (Figure 6). See Appendix A for monitoring site details.

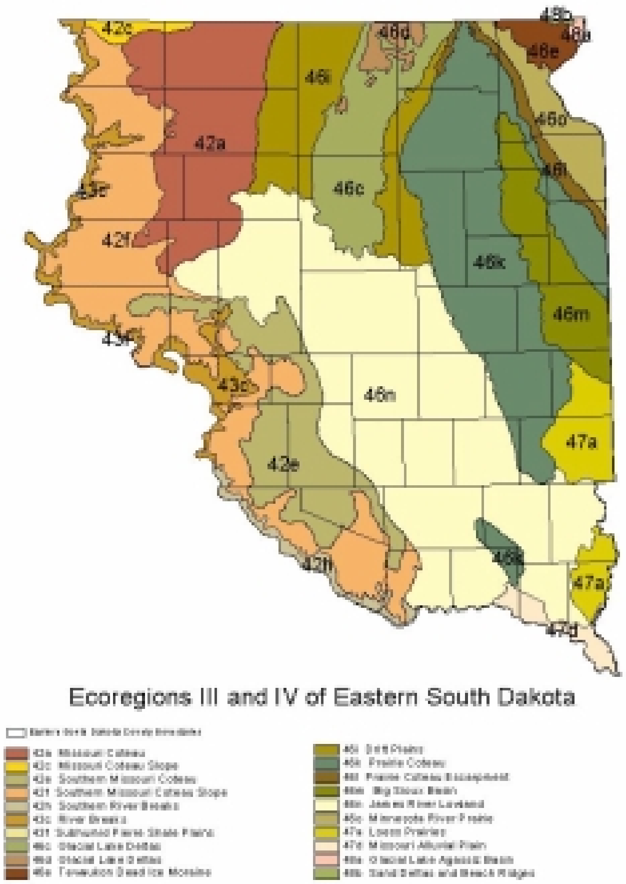


Figure 5. Ecoregions III and IV of Eastern South Dakota

Table 4. Description of Level IV Ecoregions *Within* the Central Big Sioux River Watershed (Omernik et al. 1987)

Ecoregion	Physiography	Potential Natural Vegetation	Land Use and Land Cover	Climate	Soil Order
Northern Glaciated Plains					
Prairie Coteau	Surficial geology of glacial till. Hummocky, rolling landscape with high concentration of lakes and wetlands and poorly defined stream network.	Big bluestem, little bluestem, switchgrass, indiangrass, and blue gramma.	Rolling portions of landscape primarily in pastureland. Flatter portions of landscape in row crop, primarily of corn and soybeans. Some small grain and alfalfa.	Mean annual rainfall of 20-22 inches. Frost-free from 110-140 free days.	Mollisols
Big Sioux Basin	Surficial geology of glacial till. Rolling landscape with defined stream network and few wetlands.	Tallgrass prairie: Big bluestem, little bluestem, switchgrass, indiangrass, sideoats gramma, and lead plant. Riparian areas: willows and cordgrass to the north and some woodland south.	Row crop agriculture of mostly corn and soybean. Some small grain and alfalfa.	Mean annual rainfall of 20-22 inches. Frost-free from 110-140 free days.	Mollisols
Western Corn Belt Plains					
Loess Prairies	Loess deposits. Within the assessment boundaries, Gently rolling landscape in the northern parts giving way to a well-defined stream network in the southern part.	Tallgrass prairie: Big bluestem, little bluestem, green needlegrass. On steeper slopes of southern area: needleandthread and prairie dropseed, and some deciduous trees.	Intensive row crop agriculture. Some urban development especially in Sioux Falls area.	Mean annual rainfall of 23-25 inches. Frost-free from 135-165 days.	Mollisols

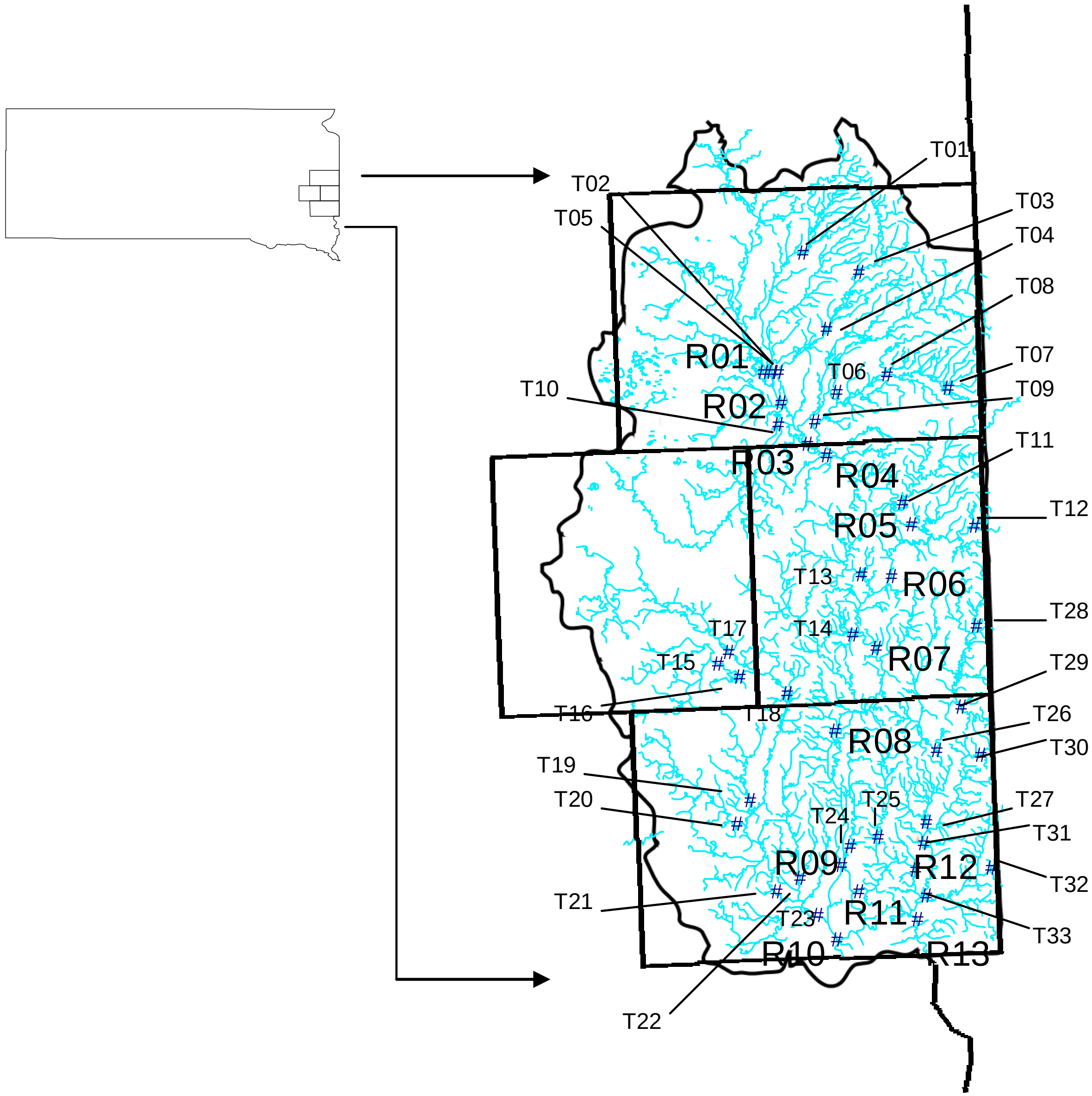


Figure 6. Location of Monitoring Sites

BENEFICIAL USES

The State of South Dakota has assigned all of the water bodies that are situated within its borders a set of beneficial uses. Beneficial use means the purpose or benefit to be derived from a water body. Under state and federal law, the beneficial use of water is to be protected from degradation. Two of the eleven beneficial uses, (9) fish and wildlife propagation, recreation and stock watering, and (10) irrigation, are assigned to all streams in the state. A set of standards is applied to the BSR and major tributaries that flow into the river. These standards must be met to maintain the beneficial uses for a particular water body. According to the 2006 Integrated Report for Surface Water Quality Assessment, several designated beneficial uses of the central Big Sioux River are impaired by total suspended solids (TSS) and fecal coliform bacteria, which have been found during the surface water quality monitoring program, to regularly exceed standards. Probable source categories identified in the report are non-irrigated cropland, pastureland, and animal holding/management areas. Most of the Big Sioux River is classified as "non-support" of aquatic life beneficial uses. In addition, Pipestone Creek and Skunk Creek, which are tributaries to the central Big Sioux River, were identified in the past as having excessive TSS and siltation. The 2006 IR 303(d) waterbody list included the Big Sioux River near Brookings, Dell Rapids, and Sioux Falls. Designated beneficial uses to the central Big Sioux River near these cities and numeric water quality standards not to be exceeded for these uses are listed in Table 5.

All river sites are assigned beneficial uses one, five, eight, nine, and ten. River sites R08 through R13 were also assigned beneficial use seven. None of the tributaries were assigned beneficial use one, but all varied in their assigned beneficial uses (refer to Table 6). See Table 5 for numeric criteria assigned to the beneficial uses.

Table 5. Numeric Criteria Assigned to Beneficial Uses of Surface Waters for the Central Big Sioux River and Tributaries

Parameters (mg/L) except where noted	**1** Domestic water supply	**5** Warmwater semipermanent fish life propagation	**6** Warmwater marginal fish life propagation	**7** Immersion recreation	**8** Limited contact recreation	**9** Fish & wildlife propagation, recreation & stock watering	**10** Irrigation
Fecal Coliform (per 100 mL) May 1 - Sept. 30				≤ 200 (mean) ≤ 400 (single sample)	≤ 1,000 (mean) ≤ 2,000 (single sample)		
Specific Conductivity (umhos/cm @ 25° C)						≤ 4,000[1]/ 7,000[2]	≤ 2,500[1]/ 4,375[2]
Nitrogen, unionized ammonia as N		≤ 0.04[1]/ 1.75x the criterion	≤ 0.05[1]/ 1.75x the criterion				
Nitrogen, Nitrates as N	≤ 10.0					≤ 50[1]/ 88[2]	
Dissolved oxygen		≥ 5.0	≥ 4.0	≥ 5.0	≥ 5.0		
pH (standard units)	≥ 6.5 - ≤ 9.0	≥ 6.5 - ≤ 9.0	≥ 6.0 - ≤ 9.0			≥ 6.0 - ≤ 9.5	
Suspended solids		≤ 90[1]/ 158[2]	≤ 150[1]/ 263[2]				
Total dissolved solids	≤ 1,000[1]/ 1,750[2]					≤ 2,500[1]/ 4,375[2]	
Temperature (°F)		≤ 90	≤ 90				

Note: [1] 30-day average [2] daily maximum

Table 6. Monitoring Sites and Their Beneficial Use Classification

		Beneficial Use Classification						
Water Body	**Site ID**	**1**	**5**	**6**	**7**	**8**	**9**	**10**
Big Sioux River	R01	■	■			■	■	■
Big Sioux River	R02	■	■			■	■	■
Big Sioux River	R03	■	■			■	■	■
Big Sioux River	R04	■	■			■	■	■
Big Sioux River	R05	■	■			■	■	■
Big Sioux River	R06	■	■			■	■	■
Big Sioux River	R07	■	■			■	■	■
Big Sioux River	R08	■	■		■	■	■	■
Big Sioux River	R09	■	■		■	■	■	■
Big Sioux River	R10	■	■		■	■	■	■
Big Sioux River	R11	■	■		■	■	■	■
Big Sioux River	R12	■	■		■	■	■	■
Big Sioux River	R13	■	■		■	■	■	■
North Deer Creek	T01			■		■	■	■
North Deer Creek	T02			■		■	■	■
Six Mile Creek	T03			■		■	■	■
Six Mile Creek	T04			■		■	■	■
Six Mile Creek	T05			■		■	■	■
Deer Creek	T06			■		■	■	■
Medary Creek	T07						■	■
Medary Creek	T08						■	■
Medary Creek	T09			■		■	■	■
Lake Campbell Outlet	T10						■	■
Spring Creek	T11			■		■	■	■
Flandreau Creek	T12			■		■	■	■
Jack Moore Creek	T13			■		■	■	■
Bachelor Creek	T14			■		■	■	■
North Buffalo Creek	T15						■	■
Buffalo Creek	T16						■	■
Brant Lake Outlet	T17			■		■	■	■
Skunk Creek (upper)	T18			■		■	■	■
Colton Creek	T19						■	■
W. Branch Skunk Creek	T20						■	■
Skunk Creek (middle)	T21			■		■	■	■
Willow Creek	T22						■	■
Skunk Creek (lower)	T23			■		■	■	■
Silver Creek	T24						■	■
Slip Up Creek	T25						■	■
W. Pipestone Creek (upper)	T26						■	■
W. Pipestone Creek (lower)	T27						■	■
Pipestone Creek (upper)	T28		■		■	■	■	■
Pipestone Creek (lower)	T29		■		■	■	■	■
Split Rock Creek (upper)	T30		■		■	■	■	■
Split Rock Creek (lower)	T31		■		■	■	■	■
Beaver Creek (upper)	T32			■		■	■	■
Beaver Creek (lower)	T33			■		■	■	■

RECREATIONAL USE

State, county, and local parks are located throughout the central region of the Big Sioux Basin. The Big Sioux State Recreation Area on the western edge of Brandon, provides camping, canoeing, and hiking. Other parks near Sioux Falls include Aspen and McHardy Parks. Table 7 lists the public recreational areas located in the study area.

Table 7. Public Recreation Areas Within the CBSRW Study Area

County	City	Public Recreational Areas
Brookings	Brookings	McCrory Gardens City Park-Hillcrest, Pioneer, and Sexauer
Lake	Chester	Brant Lake Access Area
Minnehaha	Brandon	Big Sioux Recreation Area City Parks-Aspen and McHardy
	Colton	Colton City Park
	Dell Rapids	City Parks-Brown Memorial, Dell Rapids, and Dells of the Sioux
	Garretson	Palisades State Park Beaver Creek Nature Area
	Hartford	Hartford City Park
	Sioux Falls	City Parks-Cherry Rock, Dunham, Elmwood, Falls, Fawick, Frank Olson, Great Bear, Kenny Anderson, Kuehn, Laurel Oak, Lewis, Lion's Centennial, McKennan, Morningside, Pioneer, Riverdale, Rotary, Sertoma, Spellerberg, Spencer, Terrace, Tomar, Tuthill, and Yankton Trail Outdoor Campus/Sertoma Butterfly House

THREATENED AND ENDANGERED SPECIES

Information from South Dakota Game, Fish and Parks, USGS, and the USFWS were used to construct the following table (Table 8) of the threatened and endangered species that may be found within the CBSR watershed study area. Specie status, within the study area is identified as endangered, threatened, rare, or candidate. The county in which each may be found is given, along with the occurrence of each. The Trout Perch (*Percopis omiscomaycus*) and the Topeka Shiner (*Notropis topeka*) were found in tributaries located in Brookings and Minnehaha counties, with numbers ranging from one to 311. The Whooping Crane, the American Burying Beetle, the Dakota Skipper, the Western Prairie Fringed Orchid, the Blanding's Turtle, the Lined Snake, and the Black-Footed Ferret are listed by the USFWS as species that have historically been found to occur in the CBSRW and could possibly still be in the area. The Bald Eagle, Central Mudminnow, Northern Redbelly Dace, Regal Fritillary, and the Spiny Softshell Turtle are listed as species that are commonly found within the area. However, none of these species were encountered during the study.

Table 8. Endangered, Threatened, and Candidate Species of the CBSRW Area

NAME	SCIENTIFIC NAME	CATEGORY	STATUS FEDERAL	STATUS STATE	COUNTY	OCCURRENCE
Whooping Crane	*Grus americana*	Bird	FE	SE	Brookings	Rare
Bald Eagle	*Haliaeetus leucocephalus*	Bird	FT	SE	Brookings, Lake, Moody, Minnehaha	Common
Topeka Shiner	*Notropis topeka*	Fish	FE		Brookings, Lake, Moody, Minnehaha	Common
Central Mudminnow	*Umbra limi*	Fish		SE	Brookings	Common
Trout Perch	*Percopsis omiscomaycus*	Fish		ST	Moody, Minnehaha	Common
Northern Redbelly Dace	*Phoxinus eos*	Fish		ST	Brookings	Common
American Burying Beetle	*Nicrophorus americanus*	Insect	FE		Brookings	Rare
Dakota Skipper	*Hesperia dacotae*	Insect	FC	SR	Brookings, Moody	Rare
Regal Fritillary	*Speyeria idalia*	Insect	FC		Brookings, Lake, Moody, Minnehaha	Common
Western Prairie Fringed Orchid	*Platanthera praeclara*	Plant	FT		Brookings, Moody, Minnehaha	Rare
Blanding's Turtle	*Emydoidea blandingii*	Reptile		SE	Minnehaha	Rare
Spiny Softshell Turtle	*Apalone spinifera*	Reptile		ST	Minnehaha	Common
Northern Redbelly Snake	*Storeria occipitomaculata occipitomaculata*	Reptile		ST	Brookings, Minnehaha	Common
Lined Snake	*Tropidoclonion lineatum*	Reptile		SE	Minnehaha	Rare
Black-Footed Ferret	*Mustela nigripes*	Mammal	FE	SE	Lake	Rare

KEY TO CODES:

FE = Federal Endangered	SE = State Endangered
FT = Federal Threatened	ST = State Threatened
FC = Federal Candidate	SR = State Rare

PROJECT GOALS, OBJECTIVES, AND MILESTONES

GOALS

The goals of this assessment project are to:

1) Determine and document sources of impairments to the central portion of the BSR watershed in eastern South Dakota
2) Identify feasible restoration alternatives to support watershed implementation projects to improve water quality impairments within the watershed
3) Develop TMDL based on identified pollutants

Impairments cited in the 1998, 2000, and 2004 305(b) Water Quality Assessment Report and the 1998, 2002 and 2004 South Dakota 303(d) Waterbody List for this portion of the BSR watershed are excessive pathogens (fecal coliform bacteria) and suspended solids.

Goals were accomplished through the collection of tributary and river data and aided by the completion of the FLUX, Sediment Delivery Model (SDM) and the Agricultural Non-Point Source (AGNPS) watershed modeling tools. Through data analysis and modeling, the identification of impairment sources was possible. The identification of these impairment sources will aid the state's nonpoint source (NPS) program by allowing strategic targeting of funds to portions of the watershed that will provide the greatest benefit per expenditure.

OBJECTIVES

Objective 1. Water Quality Assessment

Water sampling of river and tributary sites began in July 1999. However, this was accomplished in two phases. The first phase included 7 river sites and 14 tributary sites sampled from July 1999 through October 1999 and then again from March 2000 thorough October 2000. The second phase included 6 river sites and 19 tributary sites. Data was collected from June 2000 through October 2000 and again from April 2001 through October 2001 (See Table 9).

Detailed level and flow data were entered into a database that was used to assess the nutrient and solids loadings. Stevens Type F Stage Recorders, Solinst Leveloggers, as well as Thalmedies Hydrometers or OTTs were installed at the pre-selected monitoring sites along the tributaries.

Objective 2. Quality Assurance/ Quality Control (QA/QC)

Duplicate and blank samples consisted of ten percent of all samples and were collected during the course of the project to provide defendable proof that sample data were collected in a scientific and reproducible manner. QA/QC data collection began in July of 1999 and was completed on schedule in October of 2001 (See Table 9).

Objective 3. Watershed Modeling

Four models were incorporated into this project to analyze and predict loadings. The FLUX model was used to calculate loadings and concentrations in monthly, yearly, and daily increments. Reductions for TSS were acquired with the help of the FLUX model. The Sediment Delivery Model (SDM) was used to predict sediment loads based on rainfall events. This model was also used to determine potential sediment loading reductions with the implementation of BMPs. AGNPS was used to model feedlot runoff loads and to help pinpoint areas of concern. Load duration intervals and hydrologic conditions were used to calculate fecal coliform loads and predict reductions to meet water quality standards (See Table 9).

Objective 4. Information and Outreach

Several field trips were organized where knowledge about the project was provided as well as demonstrations about field operations. Assessments of the conditions of animal feeding operations located within the project area were conducted by contacting landowners individually. Press releases were also provided to local papers at various points throughout the project (See Table 9).

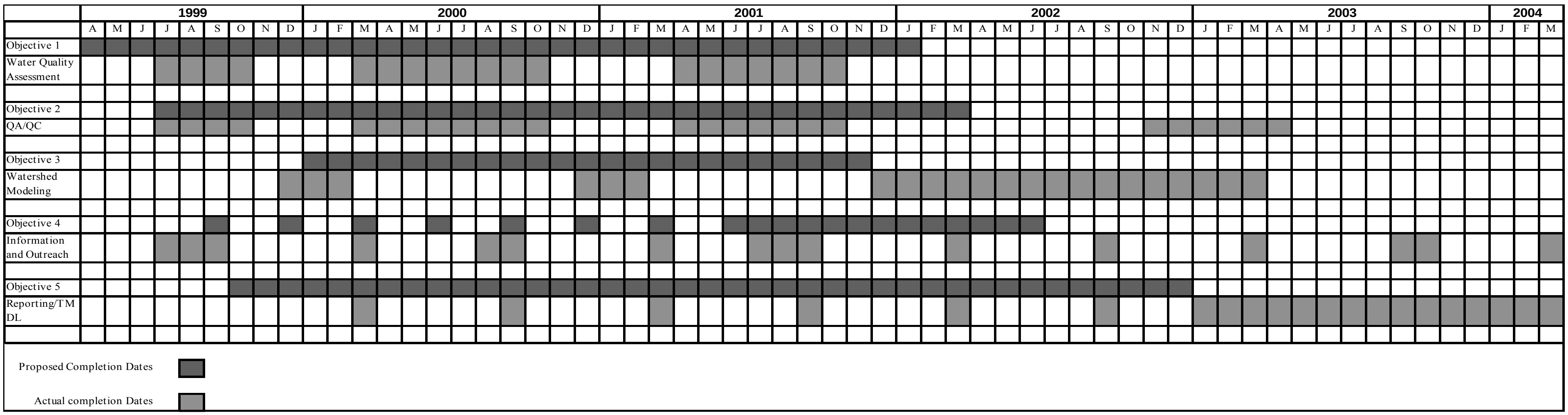
Objective 5. Reporting/TMDL Determination

When a waterbody is listed on a state's 303(d) list, TMDL's must be developed for that waterbody at levels that meet water quality standards that support the designated beneficial uses, shown previously on page 11. A TMDL is a tool or target value that is based on the linkages between water quality conditions and point and non-points sources of pollution. Based upon these linkages, maximum allowable levels of pollution are allocated to the different sources of pollution so that water quality standards are attainable. Sources that exceed maximum allowable levels (or loadings), as shown on Table 5, must be addressed in an implementation plan that calls for management actions that reduce loadings (1998 and 2002 SD 303(d) Waterbody List). Furthermore, an implementation plan can call for protection of areas that are below allowable levels. Identifying the causes and sources of water quality impairments is a continuation of the process that placed the waterbody on the 303(d) list. In the case of the central Big Sioux River, high levels of TSS and fecal coliform bacteria and the probable non-point sources identified in the 305(b) water quality assessment, guided the strategy for this assessment.

MILESTONES

The Central Big Sioux River Watershed Assessment Project was scheduled to start in April 1999; however, actual monitoring was delayed until July of 1999 due to the fact that monitoring equipment needed to be purchased and addition staff were hired. The following table shows the proposed completion dates versus the actual completion dates of the project goals, objectives, and activities.

Table 9. Milestones - Proposed and Actual Objective Completion Dates



METHODS

ENVIRONMENTAL INDICATORS

Water Quality Monitoring

Water samples were collected from 13 river sites and 33 tributary sites. The samples were scheduled for collection to coincide with spring runoff and storm events, and at base flow conditions. A total of 834 samples were collected over a two and a half year period from July 1999 through October 2001. This included 678 standard samples, 73 blank samples, and 83 duplicate samples.

Field measurements included dissolved oxygen, pH, turbidity, air temperature, water temperature, conductivity, salinity, stage, and general climatic information. A Hanna Instruments 9025 meter was used to measure pH. Salinity, DO, water temperature, and conductivity were measured using a YSI 85 meter. Turbidity was measured using a LaMotte 2020 turbidity meter and a mercury thermometer was used to measure air temperature.

The Water Resource Institute (WRI) at South Dakota State University (SDSU), performed analysis on all samples for total solids, total suspended solids (TSS), ammonia, nitrate-N, total Kjeldahl nitrogen, organic nitrogen, total phosphorus, and total dissolved phosphorous. The Sioux Falls Health Laboratory analyzed all samples for fecal coliform bacteria. Appendix B contains all grab sample data for each monitoring site.

Six of the sampling sites were also monitored by the state of South Dakota as part of the DENR Ambient Surface Water Quality Monitoring program. The TSS, ammonia, and fecal coliform data was incorporated into our reduction prediction database and analyzed in conjunction with our data.

Historical flow data monitored by the USGS was also utilized in our analysis. The following table (Table 10) depicts the USGS and DENR sites that coincided with EDWDD monitoring sites.

Table 10. Project Sites Coinciding with DENR and USGS Monitoring Locations

EDWDD Site	DENR Site	USGS Site
R01	WQM 62	
R03	WQM 2	
R04		6480000
R05	BS 18	
R08	WQM 3	6481000
R09	BS 23	
R10		6482000
R11*	BS 29 (1 mi DS)	6482020
R12**	WQM 31	6482100
T04		6479910
T09		6479980
T11		6480400
T12		6480650
T18		6481480
T23	WQM 121	6481500
T31		6482610

* for TMDL purposes includes WQ data from WQM 64 (near John Morell) located just upstream from monitoring site

** for TMDL purposes includes WQ data from WQM 117 (near SF WWTF) located just upstream from monitoring site

Description of Parameters

Water quality was sampled according to the SD DENR protocols (Stueven et al. 2000). Water quality analyses provided concentrations for a standard suite of parameters (Table 11). The detection limits are set by the WRI lab based on lab equipment sensitivity.

Table 11. Water Quality Parameters Analyzed and Laboratory Detect Limits

Parameter	Units	Lower Detect Limit
Total suspended solids	mg/L	1
Total solids	mg/L	1
Nitrates	mg/L	0.01
Ammonia-nitrogen	mg/L	0.01
Organic nitrogen	mg/L	0.01
TKN	mg/L	0.01
Total phosphorus	mg/L	0.01
Total dissolved phosphorus	mg/L	0.01
Fecal Coliform*	cfu/100 mL	<1, <10, <100

* tested by Sioux Falls Health Lab

Fecal Coliform Bacteria

Fecal coliform are bacteria that are found in the environment and are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. They indicate the possible presence of pathogenic bacteria, viruses, and protozoans that also live in human and animal digestive systems. These bacteria can enter the river and tributaries by runoff from feedlots, pastures, sewage treatment plants, and seepage from septic tanks. Major sources in the Central BSR drainage are most likely livestock and possibly human sewage.

Total Solids

Total Solids are materials, suspended or dissolved, present in natural water. Sources of total solids include industrial discharges, sewage, fertilizers, road runoff, and soil erosion.

Total Suspended Solids

TSS is the portion of total solids that are suspended in solution, whereas dissolved solids make up the rest of the total. Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. Higher TSS can increase surface water temperature and decrease water clarity. Suspended solids are the materials that do not pass through a filter, e.g. sediment and algae. Subtracting suspended solids from total solids derives total dissolved solids concentrations. Suspended volatile solids are that portion of suspended solids that are organic (organic matter that burns in a 500^{o} C muffle furnace).

Ammonia

Ammonia is the nitrogen product of bacterial decomposition of organic matter and is the form of nitrogen most readily available to plants for uptake and growth. Sources of ammonia in the watershed may come from animal feeding areas, decaying organic matter, bacterial conversion of other nitrogen compounds, or industrial and municipal surface water discharges.

Un-Ionized Ammonia

Un-ionized ammonia is the fraction of ammonia that is toxic to aquatic organisms. The concentration of un-ionized ammonia is calculated and dependent on temperature and pH. As temperature and pH increase so does the percent of ammonia which is toxic to aquatic organisms. Since pH, temperature and ammonia concentrations are constantly changing, un-ionized ammonia is calculated instantaneously (by sample) to determine compliance with tributary water quality standards rather than from a loading basis.

Nitrate-Nitrite

Nitrate and nitrite are inorganic forms of nitrogen easily assimilated by algae and other macrophytes. Sources of nitrate and nitrite can be from agricultural practices and direct input from septic tanks, precipitation, groundwater, and from decaying organic matter. Nitrate-nitrite can also be converted from ammonia through denitrification by bacteria. The process increases with increasing temperature and decreasing pH.

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is used to calculate organic nitrogen. TKN minus ammonia derives organic nitrogen. Sources of organic nitrogen can include release from dead or decaying organic matter, septic systems or agricultural waste. Organic nitrogen is broken down to more usable ammonia and other forms of inorganic nitrogen by bacteria.

Total Nitrogen

Total nitrogen is the sum of nitrate-nitrite and TKN concentrations. Total nitrogen is used mostly in determining the limiting nutrient, either nitrogen or phosphorus. Nitrogen was analyzed in four forms: nitrate/ nitrite, ammonia, and Total Kjeldahl Nitrogen (TKN). From these four forms, total, organic, and inorganic nitrogen may be calculated. Nitrate and nitrite levels are usually caused from fertilizer application runoff. High ammonia concentrations are directly related to sewage and fecal runoff. Nitrogen is difficult to manage because it is highly soluble and very mobile in water.

Total Phosphorus

Phosphorus differs from nitrogen in that is not as water-soluble and will attach to fine sediments and other substrates. Once attached, it is less available for uptake and utilization. Phosphorus can be natural from geology and soil, from decaying organic matter, waste from septic tanks or agricultural runoff. Nutrients such as phosphorus and nitrogen tend to accumulate during low flows because they are associated with fine particles whose transport is dependent upon discharge (Allan 1995). These nutrients are also retained and released on stream banks and floodplains within the watershed. Phosphorus will remain in the sediments unless released by increased stage, discharge, or current.

Total Dissolved Phosphorus

Total dissolved phosphorus is the fraction of total phosphorus that is readily available for use by algae. Dissolved phosphorus will attach to suspended materials if they are present in the water column and if they are not already saturated with phosphorus. Dissolved phosphorus is readily available to algae for uptake and growth.

Dissolved Oxygen

Dissolved oxygen is important for the growth and reproduction of fish and other aquatic life. Solubility of oxygen generally increases as temperature decreases, and decreases with lowing atmospheric pressure. Stream morphology, turbulence, and flow can also have an affect on oxygen concentrations. Dissolved oxygen concentrations are not uniform within or between stream reaches. A stream with running water will contain more dissolved oxygen than still water. Cold water holds more oxygen than warm water. Dissolved oxygen levels of at least 4-5 mg/L are needed to support a wide variety of aquatic life. Very few species can exist at levels below 3 mg/L.

pH

pH is based on a scale from 0 to 14. On this scale, 0 is the most acidic value, 14 is the most alkaline value, and 7 represents neutral. A change of 1 pH unit represents a 10-fold change in acidity or alkalinity. The range of freshwater is 2-12. pH is a measure of hydrogen ion activity, the more free hydrogen ions (more acidic), the lower the pH in water. Values outside the standard (pH 6.0 – 9.5) do not meet water quality standards.

Water Temperature

Water temperature affects aquatic productivity and water chemistry, including the levels of DO and un-ionized ammonia. Temperature extremes are especially important in determining productivity of aquatic life from algae to fish.

Conductivity

Conductivity is the measurement of the conductive material in the sample without regard to temperature. In streams and rivers, conductivity is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity, and areas with clay soils tend to have higher conductivity. Discharges into streams can also change the conductivity. In general, a higher conductivity indicates that more material is dissolved material, which <u>may</u> contain more contaminants.

Specific Conductivity

Also known as temperature compensated conductivity which automatically adjusts the reading to a calculated value which would have been read if the sample had been at 25^{o} C. The ability of water to conduct an electrical current, which is the measure of the quantity of ions in the water. It is determined by the presence of inorganic dissolved solids, such as salts. Specific conductivity is generally found to be a good measure of the concentration of total dissolved solids (TDS) and salinity.

Salinity

Salinity is the natural concentration of salts in water. This is influenced by the geologic formations underlying the area. Salinity is lower in areas underlain by igneous formations and higher in areas underlain by sedimentary formations.

Turbidity (NTU)

Turbidity or water clarity is a measure of how much the passage of light is restricted by suspended particles. Turbidity is measured in nephelometric turbidity units (NTUs). High NTU levels may increase temperatures, lower dissolved oxygen levels, and reduce photosynthesis. High NTU can clog fish gills, which lowers growth rate and resistance to disease; and it can smother fish eggs and macro invertebrates. Sources of turbidity include soil erosion, waste discharge, urban runoff, eroding stream banks, and excessive algae growth.

Sampling

Samples were collected between the spring of 1999 and the fall of 2001, during base flows and storm events. Samples were collected using the State of South Dakota standard operating procedures for field sampling. Water samples were then filtered, preserved, and packed in ice for delivery to the WRI at SDSU in Brookings, SD and the Sioux Falls Health Laboratory in Sioux Falls, SD. The following parameters (Table 12) were analyzed:

Table 12. Water Quality Parameters and Their Abbreviations

Parameter	Abbreviation
Fecal Coliform Bacteria	CFU
Total Solids	TotSol
Total Suspended Solids	TSS
Nitrate Nitrogen	NO2NO3
Total Kjeldahl Nitrogen	TKN
Organic Nitrogen	OrgNtr
Ammonia	NH3NH4
Total Phosphorous	TotPO4
Total Dissolved Phosphorous	TotDisPO4

Stream, climatic, and weather conditions were also recorded at the time of sampling. See Appendix C for water quality field data sheets.

Flow and Discharge Gaging

A total of 33 tributary monitoring sites were selected along the Big Sioux River and continuous stream flow records were collected using stage recorders. The sites were selected to determine which portions of the watershed were contributing the greatest amount of nutrient and sediment load to the river. Ten of the sites were equipped with Stevens Type F stage recorders, seven of the sites had Solinst model 3001 leveloggers, and the remaining sites had OTT Thalimedes hydrometers. Two sites used Solinst leveloggers for the first season and three months of the second season. They were then replaced by Thalimedes hydrometers for the remainder of the second season. See Appendix D for stage recorder start and end dates. Water stages were monitored and recorded to the nearest 1/100th of a foot for each of the sites. A USGS top setting wading rod with either a type AA or pygmy current meter and a CMD 9000 digimeter were used to determine flows at various stages. In the much larger streams, a USGS Type A crane with four-wheel truck was used to record flow data.

All sites were also installed with USGS Style C staff gauges as a quality control check for the installed meters. Recorded stages and flows were used to create stage-discharge tables and curves for each site (Gordon et al. 1992). USGS gaging station data was acquired for all the river sites. Streamflow records for non-gauged river sites were derived using interpolation methods (Gordon et al. 1992). Stage to discharge tables and curves can be found in Appendix E. Equations used to find discharges for each monitoring site can be found in Appendix F.

Load Duration Curves

Load duration curves were constructed for all the Big Sioux River monitoring sites to use as a tool for differentiating pollutant problems over an entire flow regime and were used as visual aids during analysis. These curves represent the percentage of time during which a load is equaled or exceeded.

Load duration curves are developed using an average daily, long-term record of stream flow. Several mainstem BSR sites had been, or are currently, being monitored by the USGS (See Table 13). The USGS data that was available and used to construct these curves is considered provisional data, subject to revisions at any time. Daily average flows for ungaged mainstem sites were derived using the drainage-area ratio method. This method is commonly used to find flow of an ungaged site that is in close proximity a gaged site on the same stream. The drainage area of the ungaged site should be within 0.5 and 1.5 times the drainage area of the gaged site.

Table 13. Descriptions of Stream Gaging Stations Analyzed with the Drainage-Area Ratio Method

EDWDD Site	USGS Site evaluated	Period of Record	Drainage Area mi^2	Ungaged DA/ Gaged DA ratio	Ecoregion
R01	06480000	---	3190	1.22	NGP
R02	06480000	---	3406	1.14	NGP
R03	06480000	---	3727	1.05	NGP
R04	* 06480000	1953-present	3898	---	NGP
R05	06480000	---	4031	.97	NGP
R06	06481000	---	4098	1.07	WCBP
R07	06481000	---	4303	1.02	WCBP
R08	* 06481000	1948-present	4389	---	WCBP
R09	06481000	---	4424	.99	WCBP
R10	* 06482000	1943-1960	5022	---	WCBP
R11	* 06482020	1971-present	5216	---	WCBP
R12	* 06482100	1959-1972	5269	---	WCBP
R13	06482100	---	5549	.95	WCBP

Sites should also be within the same ecoregion and have similar topography (FDEP 2003). The following calculation was used:

To find flow per area of the gaged site:

$$\text{gaged site flow} \div \text{gaged site drainage area mi}^2 = \text{gaged site flow per area (mi}^2\text{)}$$

To find the flow of the ungaged site:

$$\text{gaged site flow per area} \times \text{ungaged site drainage area mi}^2 = \text{ungaged site flow}$$

Daily average flows over approximately a 20-year period of time were ranked from highest to lowest. The percent of days each flow was exceeded was calculated by dividing each rank by the number of flow data points.

$$\text{rank} \div \text{number of data points} = \text{percent of days the flow was exceeded}$$

Next, a load needs to be calculated. This is done by multiplying each average daily flow by the water quality standard for the parameter and multiplying by the conversion factor.

$$\text{flow (cfs)} \times \text{standard (mg/L)} \times \text{conversion factor} = \text{load}$$

The conversion factor for converting the mg/L to pounds per day for TSS is 5.396, as shown by the following formula:

$$\frac{\text{mg}}{\text{L}} \times \frac{1\ \text{L}}{.0353146667\ \text{ft}^3} \times \frac{86400\ \text{sec}}{1\ \text{day}} \times \frac{\text{ft}^3}{\text{sec}} \times \frac{1\ \text{lb}}{453592.37\ \text{mg}} = \text{lbs/day}$$

The conversion factor for converting cfu/100mL to colonies per day for fecal coliform bacteria is 24,468,480 as shown by the following formula:

$$\frac{\text{col}}{\text{day}} \times \frac{28320\ \text{mL}}{1\ \text{ft}^3} \times \frac{86400\ \text{sec}}{1\ \text{day}} \times \frac{\text{ft}^3}{\text{sec}} = \text{col/day}$$

The actual load duration curve is formed by plotting the load against the percent days flow exceeded (NDEP 2003). A second load duration curve can be plotted to represent a 10 percent margin of safety (MOS). To plot the grab sample data, a daily load for each sample is calculated. The streamflow for each day is found and the value for percent of days that load exceeded from the previous data (See Figure 7). The loads and percent days exceeded are plotted.

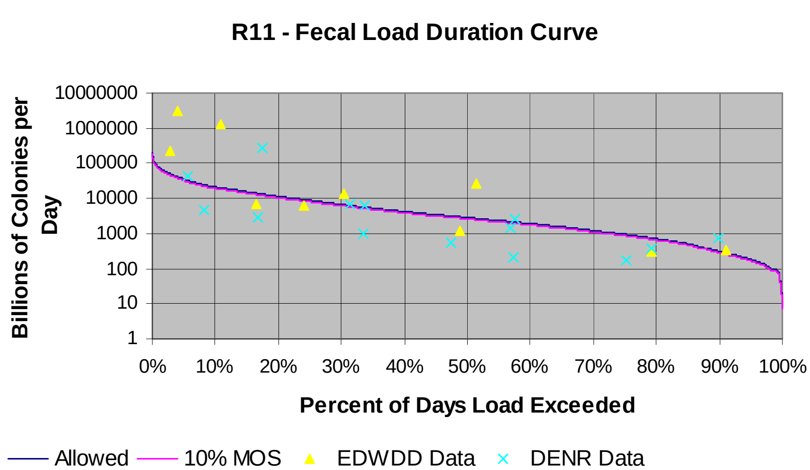


Figure 7. Example of a Load Duration Curve

Biological Monitoring

Rivers and streams in the Big Sioux River watershed did not have an established biological assessment framework. This project adopted the multimetric approach to biological data analysis (Barbour et al. 1999). This approach involved two phases with the process and rationale outlined in Table 14.

Table 14. Process of Developing Biological Indicators for the CBSRW

Phase I. Development of Biological Indicators	
1. Stream Classification	Stream classifications group sites that share naturally similar physical and chemical characteristics. Grouped sites are expected to have similar biology under natural conditions and respond similarly to human disturbances.
2. Candidate Metric Identification	A list of candidate metrics (i.e., biological traits) that have the potential to be responsive to stressors is developed. This list is composed of metrics that are relevant to the region's stream ecology and represents aspects of community richness, composition, tolerance, trophic structure, and individual health.
3. Select Core Metrics	Metrics from the candidate list are selected based on their ability to discriminate between least-impacted sites and most-impacted sites. A set of core metrics is produced that represents aspects of community richness, composition, tolerance, trophic structure, and individual health.
4. Index Development	An index is an aggregate of scores from selected core metrics. However, prior to aggregation, metric values must be transformed to standardized metric scores that are unitless because each metric may have different units (e.g., integers, percentages). Once scores are transformed and aggregated into an index, the ability of the index to discriminate between least impaired and most impaired sites is tested.
5. Index Thresholds Established	The range of site index scores reflects a range of biological impairment (e.g., poor, fair, good). This range of biological impairment is subdivided into classes based on thresholds that are essentially index scores that define the upper and lower limits on classes.
Phase II. Indicator Use in Assessment and Monitoring	
Assessment and Monitoring	With the above completed, the index is ready to use as a tool for assessing and monitoring the health of streams.

Fish Sampling

Fish were sampled in the tributaries with bag seines having 5 mm mesh size. Pools and runs were seined in a downstream direction with a seine that reached from bank to bank. A block net having 8 mm mesh was placed across the stream at the lower end of the reach to prevent fish from escaping. Riffles were usually sampled by kicking through the substrate in a downstream direction toward a bag seine placed across the stream at the bottom of the riffle. Collected fish were placed in holding crates. Fish were identified to species, and a representative number of each species measured (25 to 50 individuals), with external diseases, anomalies, fin damage, and parasites noted. Weighing 100 individuals and using their average weight to divide into bulk weights of uncounted individuals, estimated the number of abundant species. Collections were taken for voucher jars.

Fish Index of Biological Integrity (IBI)

The index of biological integrity for fish was constructed based upon the Rapid Bioassessment Protocol IV (RBPIV) (Barbour et al. 1999), Karr's (1981) fish community assessment, and Plafkin et al. (1989) RBP protocol for macroinvertebrates and fishes. Candidate metrics (Table 15) representative of the Midwest region were chosen to represent the categories of richness/composition, headwater/pioneering attributes, tolerance/intolerance, trophic guilds, and reproduction. Core metrics were chosen in each category through a process of comparative descriptive analysis. Appendix G describes metrics recommended for use within the Midwest region. These metric descriptions in conjunction with the descriptive analysis were used in the selection of the best possible core metrics. The basis of this selection was the ability of each metric to discriminate between sites least impacted and sites most impacted. Comparative descriptive analysis was accomplished using box and whisker plots, analyzing all monitoring sites at the same time for metrics in each of the five categories (richness/composition, headwater/pioneering attributes, tolerance, trophic guilds, and reproduction). Box plots that yielded a good spread and differing means were chosen as core metrics in each category (See Table 16). Coefficients of variation (CVs) also aided in the selection of the core metrics (See Appendix H).

Once the core metrics in Table 16 were chosen, best value percentiles were calculated. The 95th percentile was used as a basis for best value for those metrics that decreased with impairment. Those metrics that increased with impairment were given a 5th percentile as a basis for best value. Once either the 95th or 5th percentile standard was set for each metric, the actual measured metric value was compared to the standard best value to find the standardized metric score. Standardized metric scores range from 0 to 100, with 0 being very poor and 100 being excellent.

Decrease in response to impairment:

$$(\text{measured metric value}) \div (\text{standard best value} - 0) \times 100 = \text{standardized metric score}$$

Increase in response to impairment:

$$(100 - \text{measured metric value}) \div (100 - \text{standard best value}) \times 100 = \text{standardized metric score}$$

Table 15. Candidate Fish Metrics Calculated for the CBSRW

Category	#	Metric	Response to Disturbance
Species Richness and Composition	1	Total Species Richness	Decrease
	2	Native Species Richness	Decrease
	3	Native Minnow Species Richness	Decrease
	4	Water Column Species Richness	Decrease
	5	Benthic Species Richness	Decrease
	6	Benthic Insectivore Richness	Decrease
Headwater/Pioneering Attributes	7	Headwater Species Richness	Decrease
	8	% Headwater Species	Decrease
	9	% Headwater Species Biomass	Decrease
	10	% Pioneering Species	Increase
	11	% Pioneering Species Biomass	Increase
Intolerant/Tolerant Attributes	12	Intolerant Species Richness	Decrease
	13	% Intolerant Species	Decrease
	14	% Intolerant Species Biomass	Decrease
	15	Sensitive Species Richness	Decrease
	16	% Sensitive Species	Decrease
	17	% Sensitive Species Biomass	Decrease
	18	% Green Sunfish	Increase
	19	% Green Sunfish Biomass	Increase
	20	% Tolerant Species	Increase
	21	% Tolerant Species Biomass	Increase
Trophic Guilds	22	% Insectivorous Minnows	Decrease
	23	% Insectivorous Minnows Biomass	Decrease
	24	% Insectivores	Decrease
	25	% Insectivore Biomass	Decrease
	26	% Predators	Increase
	27	% Predator Biomass	Increase
	28	% Omnivores	Increase
	29	% Omnivore Biomass	Increase
	30	% Herbivores	Decrease
	31	% Herbivore Biomass	Decrease
Reproduction	31	% Simple Lithophils	Decrease
	32	% Simple Lithophil Biomass	Decrease

Table 16. Core Fish Metrics for the CBSRWA

Category	#	Metric	Response to Disturbance
Species Richness and Composition	1 2 3	Total Species Richness Native Minnow Species Richness Benthic Insectivore Richness	Decrease Decrease Decrease
Headwater/Pioneering Attributes	4 5	Headwater Species Richness % Pioneering Species	Decrease Increase
Intolerant/Tolerant Attributes	6 7	Sensitive Species Richness % Tolerant Species Biomass	Decrease Increase
Trophic Guilds	8 9	% Insectivorous Minnows % Omnivore Biomass	Decrease Increase
Reproduction	10	% Simple Lithophil Biomass	Decrease

Table 17, below, is an example of a tributary score sheet that outlines the metrics and the score assigned to each metric. After each of the twelve metrics was scored, the standardized metric scores were averaged for each monitoring site and served as the final index value for that site. Score sheets for fishes by monitoring site can be found in Appendix I.

Table 17. Sample Score Sheet for Fishes

Site T05

Metric	**Response to Impairment**	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Species Richness	Decrease	95th	20	14	70
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	21.13	79
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	55.26	53
% Insectivorous Minnows	Decrease	95th	95.63	83.02	87
% Omnivore Biomass	Increase	5th	0.24	1.79	98
% Simple Lithophil Biomass	Decrease	95th	55	13.76	25
			Final index value for this site:		**64**

Macroinvertebrate Sampling

Sampling of macroinvertebrates with kick seines, cone and flat rock baskets occurred in both the tributaries and the river sites from late August to mid October of 1999, 2000, and 2001. A kick seine was initially used at two sites in 1999. It was decided in 2000, the best method for sampling macroinvertebrates would be with rock baskets, due to the rock substrate in each basket allowing for colonization of macroinvertebrates yielding a better sample. Four baskets were placed at each site for a period of 45 days $\pm$ 3 days (See Table 18). Construction, deployment, and retrieval of rock baskets were conducted according to the SD DENR protocols (Stueven et al. 2000). Sorting, identification, and enumeration of macroinvertebrates occurred at the lowest practical taxonomic level (See Appendix J and K for outsource contracts and their laboratory procedures). Three of the four baskets, at each site, were chosen for collection and were composited into a voucher jar with the exception of six sites. Six sites were chosen based on water chemistry and visual evaluations - three were considered least impacted while the other three were considered most impacted of the sites sampled in 2001. Voucher jars were taken for each of the three rock baskets at each of the six sites. Candidate metrics (Table 19) were calculated and reduced to a set of core metrics for scoring (Tables 20 and 21).

Table 18. Macroinvertebrate Collection Information

Site Code	Site Name	Method	Deployment Date	Retrieval Date	#Days Colonized
T01	No Deer Ck (upper)	-------------------------- Dry --------------------------			
T02	No Deer Ck (lower)	-------------------------- Dry --------------------------			
T03	Six Mile Ck (upper)	---------------------- Isolated Pools -------------------			
T04	Six Mile Ck (middle)	Cone	9/13/00	10/25/00	42
T05	Six Mile Ck (lower)	------------ Kick Seine - unknown date ------------			
T06	Deer Creek	------------------ Kick Seine - 8/23/99 -------------			
T07	Medary Ck (upper)	Cone	9/1/00	10/13/00	43
T08	Medary Ck (middle)	Cone	9/1/00	10/13/00	43
T09	Medary Ck (lower)	Cone	8/29/00	10/11/00	42
T10	Lake Campbell Outlet	Flat	8/29/00	10/12/00	43
T11	Spring Creek	Cone	9/11/00	10/23/00	42
T12	Flandreau Creek	Cone	8/29/00	10/12/00	43
T13	Jack Moore Creek	Cone	9/11/00	10/23/00	42
T14	Bachelor Creek	Cone	9/11/00	10/23/00	42
T15	North Buffalo Creek	Flat	8/21/01	10/3/01	44
T16	Buffalo Creek	------------------------ DRY ---------------------------			
T17	Brant Lake Outlet	Flat	8/21/01	10/2/01	43
T18	Skunk Ck (upper)	Flat	8/21/01	10/2/01	43
T19	Colton Creek	Cone	8/21/01	10/2/01	43
T20	W. Branch Skunk Ck	Cone	8/20/01	10/1/01	43
T21	Skunk Ck (middle)	Cone	8/20/01	10/1/01	43
T22	Willow Creek	Cone	8/20/01	10/1/01	43
T23	Skunk Creek (lower)	Cone	8/20/01	10/1/01	43
T24	Silver Creek	Flat	8/22/01	10/3/01	43
T25	Slip-up Creek	Cone	9/11/00	10/25/00	44
T26	W Pipestone Ck (upper)	Flat	8/22/01	10/5/01	45
T27	W Pipestone Ck (lower)	Cone	8/22/01	10/5/01	45
T28	Pipestone Ck (upper)	Cone	8/22/01	10/4/01	44
T29	Pipestone Ck (lower)	Cone	8/22/01	10/4/01	44
T30	Split Rock Ck (upper)	Cone	8/22/01	10/4/01	44
T31	Split Rock Ck (lower)	Cone	8/22/01	10/4/01	44
T32	Beaver Ck (upper)	Cone	8/21/01	10/2/01	43
T33	Beaver Ck (lower)	Cone	8/21/01	10/2/01	43
R01	BSR nr Brookings	Cone	8/28/00	10/10/00	43
R02	BSR at Sinai Road	Cone	8/28/00	10/10/00	43
R03	BSR at Hwy 77	Cone	8/28/00	10/11/00	43
R04	BSR at USGS Brookings	Cone	8/28/00	10/11/00	43

R05	BSR nr Flandreau	Cone	8/29/00	10/11/00	42
R06	BSR at Egan	Cone	8/29/00	10/11/00	42
R07	BSR at Trent	Cone	8/29/00	10/11/00	42
R08	BSR @ USGS Dell Rapids	Cone	8/30/01	10/15/01	47
R09	BSR @ USGS HWY 38	Cone	8/30/01	10/17/01	42.5
R10	BSR @ Western Ave	Cone	8/30/01	10/17/01	49
R11	BSR @ USGS N. Cliff Ave	Cone	8/30/01	10/15/01	47
R12	BSR @ Brandon	Cone	8/30/01	10/16/01	48
R13	BSR @ Gitchie Manitou	Cone	8/30/01	10/16/01	48

Macroinvertebrate Index of Biological Integrity (IBI)

The development of the macroinvertebrate index of biotic integrity (IBI) followed the process outlined in Table 14. There were no established reference sites to base our information. Therefore, the following steps were taken to develop an index score for each site. In addition, a set of core metrics was chosen for the Big Sioux River sites and a separate table of core metrics was chosen for the tributary sites.

Candidate metrics (See Table 19) were chosen to represent the categories of abundance, richness, composition, tolerance/intolerance, and feeding. The EPA Rapid Bioassessment Protocols for Use in Streams and Rivers (Barbour et al. 1999) aided in developing these procedures. Core metrics (See Tables 20 and 21) were then chosen in each category through a process of comparative descriptive analysis. The basis of this selection was the ability of each metric to discriminate between sites least impacted and sites most impacted. Comparative descriptive analysis was done using box and whisker plots, analyzing all data from all the monitoring sites at the same time for each of the five categories (abundance, richness, composition, tolerance, and feeding). Box plots that yielded a good spread and differing means were chosen as metrics in each category. Coefficients of variation (CVs) were found by dividing the standard deviation (SD) by the mean. CVs also aided in the selection of the core metrics (See Appendix L).

Table 19. Candidate Macroinvertebrate Metrics Calculated for the CBSRWA

Category	#	Metric	Response to Disturbance
Abundance Measures	1	Abundance	Variable
	2	EPT Abundance	Decrease
Richness Measures	3	Total No. Taxa	Decrease
	4	Number of EPT Taxa	Decrease
	5	Number of Ephemeroptera Taxa	Decrease
	6	Number of Trichoptera Taxa	Decrease
	7	Number of Plecoptera Taxa	Decrease
	8	Number of Diptera Taxa	Decrease
	9	Number of Chironomidae Taxa	Decrease
Composition Measures	10	Ratio EPT/Chironomidae Abundance	Decrease
	11	% EPT	Decrease
	12	% Ephemeroptera	Decrease
	13	% Plecoptera	Decrease
	14	% Coleoptera	Decrease
	15	% Diptera	Increase
	16	% Oligochaeta	Variable
	17	% Baetidae	Increase
	18	% Hydropsychidae	Increase
	19	% Chironomidae	Increase
	20	Shannon-Weiner Index	Decrease
Tolerance/Intolerance Measures	21	Number of Intolerant Taxa	Decrease
	22	% Tolerant Organisms	Increase
	23	Hilsenhoff Biotic Index	Increase
	24	% Dominant Taxon	Increase
	25	% Hydropsychidae to Trichoptera	Increase
	26	% Baetidae to Ephemeroptera	Increase
Feeding Measures	27	% individuals as Gatherers and filterers	Decrease
	28	% Gatherers	Decrease
	29	% Filterers	Increase
	30	% Shredders	Decrease
	31	% Scrapers	Decrease
	32	Ratio Scrapers/(Scrapers+Filterers)	Decrease
	33	Number of Gatherer Taxa	Decrease
	34	Number of Filterer Taxa	Decrease
	35	Number of Shredder Taxa	Decrease
	36	Number of Scraper Taxa	Decrease
	37	Number of Clinger Taxa	Decrease
	38	% Clingers	Decrease

Table 20. Core Macroinvertebrate Metrics Calculated for Tributaries in the CBSRW

Category	#	Metric	Response to Disturbance
Abundance Measures	1	Abundance	Decrease
Richness Measures	2	Total Number of Taxa	Decrease
	3	Number of Trichoptera Taxa	Decrease
	4	Number of Diptera Taxa	Decrease
Composition Measures	5	% EPT	Decrease
	6	% Chironomidae	Increase
	7	Shannon-Weiner Index	Decrease
Tolerance/Intolerance Measures	8	% Tolerant Organisms	Increase
	9	Hilsenhoff Biotic Index	Increase
	10	% Dominant Taxon	Increase
Feeding Measures	11	% Gatherers	Decrease
	12	% Filterers	Increase
	13	% Scrapers	Decrease
	14	% Clingers	Decrease

Table 21. Core Macroinvertebrate Metrics Calculated for the Big Sioux River in the CBSRW

Category	#	Metric	Response to Disturbance
Abundance Measures	1	Abundance	Decrease
Richness Measures	2	Total Number of Taxa	Decrease
	3	Number of EPT Taxa	Decrease
	4	Number of Trichoptera Taxa	Decrease
	5	Number of Chironomidae Taxa	Decrease
Composition Measures	6	% EPT	Decrease
	7	% Coleoptera	Decrease
	8	% Chironomidae	Increase
Tolerance/Intolerance Measures	9	Number of Intolerant Taxa	Decrease
	10	% Tolerant Organisms	Increase
	11	% Dominant Taxon	Increase
Feeding Measures	12	Number of Gatherer Taxa	Decrease
	13	Number Scraper Taxa	Decrease
	14	Number of Clinger Taxa	Decrease

Once the core metrics in Tables 20 and 21 were chosen, best value percentiles were calculated. The 95th percentile was used as a basis for best value for those metrics that decreased with impairment. Those metrics that increased with impairment were given a 5th percentile as a basis for best value. Once either the 95th or 5th percentile standard was set for each metric, the actual measured metric value was compared to the standard best value to find the standardized metric score. Standardized metric scores range from 0 to 100, with 0 being very poor and 100 being excellent.

Decrease in response to impairment:

$$\text{measured metric value} \div (\text{standard best value} - 0) \times 100 = \text{standardized metric score}$$

Increase in response to impairment:

$$(100 - \text{measured metric value}) \div (100 - \text{standard best value}) \times 100 = \text{standardized metric score}$$

Table 22, below, is an example of a tributary score sheet that outlines the metrics and the score assigned to each metric. After each of the core metrics were scored, the standardized metric scores were averaged for each monitoring site and served as the final index value for that site. Score sheets for the tributary and river sites can be found in Appendix M and N, respectively.

Table 22. Sample Score Sheet for Macroinvertebrates

Site T05

Metric	**Response to Impairment**	**Percentile for "best" value**	**Standard (best value)**	**Measured metric value**	**Standardized Metric score**
Abundance	Decrease	95th	417	311	75
Taxa Richness	Decrease	95th	37.8	31	82
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95^{th}	25.6	15	59
% EPT	Decrease	95th	83.83	25.08	30
% Chironomidae	Increase	5th	3.47	59.16	42
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.15	97
% Tolerant	Increase	5th	3.89	13.50	90
HBI	Increase	5th	4.66	5.47	85
% Dominant	Increase	5th	14.94	21.86	92
% Gatherers	Decrease	95th	69.38	25.4	37
% Filterers	Increase	5th	1.96	7.07	95
% Scrapers	Decrease	95th	38.4	7.40	19
% Clingers	Decrease	95th	59.92	14	24
			Final index value for this site:		**66**

Although six sites had separate voucher jars for each rock basket collected, without having prior established reference type sites to base the results, there was not enough information from only three baskets and only six sites to make a good analysis. Thus, the results from the separate jars at each of the six sites were combined, per site, so they could be evaluated together with all the other sites. In addition, keeping voucher jars and baskets separate was not considered until the 2001 sampling, making it difficult to compare them to the composite samples taken in 2000.

Physical Habitat

The following procedures for field measurements of the physical characteristics of wadeable streams were a synthesis of many sources, but the basic framework was adopted from Simonson et al. (1994) and Platts et al. (1983). The data are compatible with available physical assessments (Barbour et al. 1999; Stueven et al. 2000). A list of terms and definitions are provided in Appendix O to aid use of the following procedures.

Near each monitoring site, a reach was selected that had one type and intensity of riparian landuse, and where bridges and dams appeared to have minimal impact. Data collection consisted of five components: physical, discharge, water surface slope, water quality, and reach classification.

Habitat Assessment

Field measurements of physical characteristics using a transect method were adapted from Simonson et al. (1994) and Platts et al. (1983). Field data sheets are provided in Appendix P. Reaches were selected within one type of riparian land use in most cases, and where bridges and dams appeared to have minimal impact. Once a reach was selected, a preliminary mean stream width (PMSW) was obtained and used to determine transect spacing (Simonson et al. 1994). When low flows restricted stream width to a small portion of the streambed, streambed width was used to determine transect spacing. Transects were marked with flags, then data collection began on the upstream end of the reach and proceeded downstream.

Transect data collection were divided into three practical components based on tools used. The first suite of data was collected according to visual estimates and counts. On either end of a transect the riparian land use, dominant vegetation type, animal vegetation use, dominant bank substrate, and bank slumping (presence/absence) were recorded. Where a transect crossed the stream, dominant macrohabitat type was designated as pool, riffle, or run. Bed substrate data was collected using the Wolman "pebble count" by visually dividing the transect into eight "cells". Within each cell, substrate size was measured and the class size recorded. This method objectively classified substrates in clear streams and was a necessity in turbid streams where visual estimates were not possible (Wolman 1954).

A second suite of data focused on stream bank and riparian features and was measured with a graduated pole and angle finder. After identifying the break point between the channel bank and channel bottom, measurements related to stream bank length, bank angle, and bank height were taken (See Figure 8). Along the stream bank length, the length of bank that was vegetated, eroded, and depositional was measured. Vegetated portions were that length of bank where root structure contributed to bank stability, eroded portions were that length with no root structure support, and depositional portions were that length where recent deposition dominated the bank surface. Riparian-related cover types were measured at the end of each transect as the horizontal length of overhanging vegetation (OHV) and undercut bank (UCB) extending over the streambed.

A third suite of data focused on horizontal and vertical point measurements which were used to calculate stream width, depth and velocity; channel bottom and top width; and bankfull width, depth, and width:depth ratio. At most sites, point data were obtained by staking a tape measure from left top bank to the right top bank. In some cases, the tape measure was staked at left bankfull and right bankfull. Moving from left to right, key channel features (i.e., location codes) were identified and the distance from the left stake was recorded. Vertical measurements were bankfull depth, water depth, and water velocity. Bankfull depths were measured at the water edge and at three points within the stream. Water depth and velocity were measured at the three points within the stream (1/4, 1/2, and 3/4 of the distance across the stream surface).

At each site, data were also collected on large woody debris (LWD), discharge, water surface slope, and water quality. The number of LWD was tallied for the entire reach. Length, diameter, and angle to streambank measurements of all LWD were measured and used to calculate the volume of LWD within the reach. Discharge data were collected at a single transect or other stream cross-sections where flow was uniform. The velocity-area method described in Gordon et al. (1992) was used. Water surface slope (%) was calculated by dividing the drop in water surface from transect one to transect 13 by the longitudinal stream distance using a surveying level.

Water quality data measured included water temperature, air temperature, turbidity, pH, dissolved oxygen, and conductivity. These measurements were taken once at each reach.

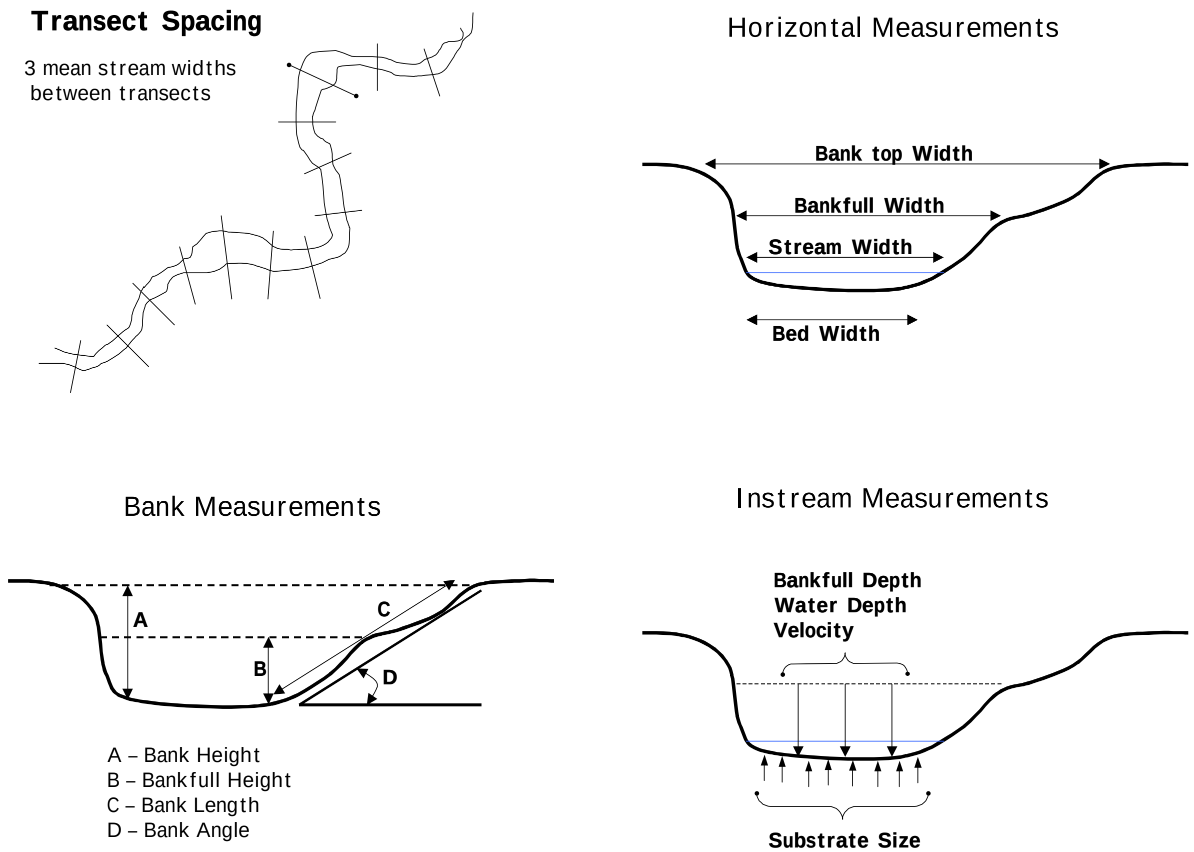


Figure 8. Diagrams of Transect Spacing, Horizontal, Bank, and Instream Measurements

Index of Physical Integrity (IPI)

The physical habitat index for the CBSRWAP was developed based on EPA's Rapid Bioassessment of substrate, channel morphology, bank structure, and riparian vegetation (Barbour et al. 1999). Parameters and scoring of each site was modified to suit this project. The following table (Table 23) outlines the parameters and the score assigned to each rating. By using the information collected on the field data sheets, each monitoring site was rated individually using the eight parameters. Scores ranged from 0 to 100. After each site was scored, a standardized metric score that was based on 'best value', was calculated and served as the final index value for that site as shown (See Table 24).

Table 23. Parameters and Scores Used to Rate the Physical Habitat Measurements

Physical Parameter	Rating				
	Excellent	**Good**	**Fair**	**Poor**	**Very Poor**
1. Channel Flow Status	Perrenial streamflow. Water surface reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Perrenial streamflows. Water surface covers <100% but >75% of the available channel bottom.	Perrenial streamflows. Water surface covers 50-75% of the available channel bottom.	Perrenial streamflows. Water surface covers >50% of the available channel bottom.	Average Stream Width about 1/3 channel bottom width. Intermittent.
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
2. Physical Complexity	high	high/moderate	moderate	moderate/low	low
	$\geq$8 hydrologic units, usually at least 3 riffles present	6 to 7 hydrologic units, usually 2 to 4 riffles present	4 to 5 hydrologic units, usually 1 to 3 riffles present	2 to 3 hydrologic units, usually 0 to 1 riffles present	1 hydrologic units, no riffles present
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
3. Coefficient of Variation of Velocity	$\geq$1.2	0.9 to 1.2	0.6 to 0.9	0.3 to 0.6	<0.3
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
4. Bed Composition	$\geq$ 75% gravel and larger	$\geq$ 75% gravel and sand (at least 50% gravel)	$\geq$ 75% coarse gravel, sand, and silt	$\geq$ 75% sand and silt (at least 50% sand)	> 75% silt or smaller
SCORE *	**16**	**12**	**8**	**4**	**0**
* Add 4 points if cobble size and larger comprise 10% of substrate					
5. Measure of Incision	Mean Bank Full Height is $\geq$70% of mean Bank Height.	Mean Bank Full Height is $\geq$60 to 69% of mean Bank Height.	Mean Bank Full Height is $\geq$50 to 59% of mean Bank Height.	Mean Bank Full Height is $\geq$40 to 49% of mean Bank Height.	Mean Bank Full Height is <40% of mean Bank Height.
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
6. Bank Stability	>80% bank vegetated; the remaining erosional or depositional.	$\geq$60 to 80% bank vegetated; the remaining erosional or depositional.	$\geq$40 to 60% bank vegetated; the remaining erosional or depositional.	$\geq$20 to 40% bank vegetated; the remaining erosional or depositional.	<20% bank vegetated; the remaining erosional or depositional.
SCORE	**20**	**15**	**10**	**5**	**0**
7. Overhanging Vegetation	Average amount $\geq$0.5 m	$\geq$0.3 - 0.49 m	$\geq$0.2 - 0.29 m	$\geq$0.1 - 0.19 m	<0.1 m
SCORE	**10**	**7.5**	**5**	**2.5**	**0**
8. Animal Vegetation Use	No Use: All the potential plant biomass is present.	Light Use: Almost all of the potential plant biomass is present.	Moderate Use: About 1/2 of plant biomass is present. Plant stubble about half potential height.	High Use: Less than 1/2 of plant biomass is present. Plant stubble greater than 2 inches.	Very High Use: Nearly all plant biomass removed. Plant stubble less than 2 inches.
SCORE	**10**	**7.5**	**5**	**2.5**	**0**

Table 24. Sample Score Sheet for Physical Habitat

SiteID: T01 **Site Name:** North Deer Ck (upper)

	Parameter	Score
1	Channel Flow Status (10)	10
2	Hydrologic Complexity (10)	10
3	CV of Velocity (10)	5
4	Bed Composition (20)	8
5	Channel Incision (10)	10
6	Bank Stability (20)	15
7	Overhanging Vegetation (10)	0
8	Animal Vegetation Use (10)	7.5
	Total =	**65.5**

From the above sample, site T01 has scored a 65.5. This was repeated for each site that had a physical habitat assessment field data sheet. Since there were no reference sites to base the information, we took the 95th percentile score of each metric based on all monitoring sites and made it the standard to base each metric score upon. The following calculation was used to find the metric score for each of the eight physical habitat parameters (See Table 25).

$$(\text{measured metric value}) \div (\text{standard best value}) \times 100 = \text{standardized metric score}$$

The final index value was found by averaging the eight standardized metric scores. The values range from 0 (very poor) to 100 (excellent). Score sheets for each site can be found in Appendix Q.

Table 25. Sample Final Score Sheet for Physical Habitat

Site T01

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	10	100
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**68**

Quality Assurance and Data Management

Quality Assurance/Quality Control (QA/QC) samples were collected for at least 10 percent of the samples taken. A total of 678 water samples were collected from 46 monitoring sites. Total QA/QC samples were 156, with 83 being duplicates and 73 blanks.

QA/QC results were entered into a computer database and screened for data errors. Overall, the duplicates produced very similar results to the sample itself, with the exception of fecal coliform counts. Variations among duplicate bacteria samples may have occurred because of bacteria variability. Differences in the results containing nitrogen (nitrate-nitrite, organic nitrogen, TKN) may be attributed to the use of reverse osmosis water for cleaning and filtering and also due to faulty lab equipment used in analysis. Unfortunately, the lab director was unable to come up with a correction factor due to the randomness of the errors. See copy of WRI lab director's memo in Appendix R.

Field blanks consistently registered detectable limits of nutrients and sediments. Sediment detects may be due to inadequate rinsing of bottles or the quality of rinsing water. Sources of the nitrogen problems may have been the quality of the rinsing water, but more likely due to faulty lab equipment used for the analysis. See Appendix S for field duplicates and blanks.

ASSESSMENT OF SOURCES

Point Sources

Wastewater Treatment Facilities (NPDES)

Data for all permitted NPDES facilities was obtained from DENR personnel in Pierre (Personal Communication SDDENR). The data was reviewed and a calculation of their contributions was made. Each facility was matched to a monitoring location within the study area. Each facility was evaluated to determine its percent contribution of fecal coliform bacteria and TSS to the downstream monitoring sites during the study period. This was accomplished by the following equations:

30-day average flow (mean) × 30-day average concentration (mean) × # of days discharged = total load

(total facility load ÷ total monitored load) × 100 = percent facility load

Municipal Separate Stormwater Sewer Systems (MS4 Phase I and II)

The City of Sioux Falls MS4 Phase I permit is non-specific in its allowable urban runoff contribution. The terms and conditions section of the permit states,

> "This permit shall require controls to reduce the discharge of pollutants from the MS4 to the maximum extent practicable based on Best Professional Judgment. There are no numeric effluent limits included in this permit. Pollution prevention and storm water management requirements are the controls that are used in place of numeric limits to achieve reductions of pollution in the storm water discharges from the city of Sioux Falls MS4 and SD DOT. The department has determined that the terms and conditions discussed below are necessary to ensure the required compliance."

According to the permit, a discharge characterization study was performed by the USGS (USGS 1996) which estimated TSS to be 10,123,188 pounds of sediment per year. There were no estimates for fecal coliform. Using this information, and the information described below under Urban Stormwater Runoff, EDWDD estimated contribution of sediment from the City of Sioux Falls vicinity. Further study of the storm water systems became necessary before MS4 fecal coliform bacteria and TSS contributions can be estimated.

On December 8, 1999, EPA promulgated Phase II of the Storm Water Regulations, which expanded the program to include point source discharges from small MS4s. The City of Brookings in 2003 had an estimated population of 18,464 and falls under the Phase II category. The permit is designed to reduce the discharge of pollutants from the MS4 to the Maximum Extent Practicable to protect water quality." In short, the permittee must develop procedures that meet the requirements of the six minimum measures and protect waters of the state from pollution, contamination, and/or degradation. Specific numbers are not required by the permit. Only that the permittee follow a certain set of guidelines recommended to minimize the impact of storm generated flows on a receiving waterbody. MS4 Phase II permit is non-specific in its allowable urban runoff contribution

Urban Stormwater Runoff

Sioux Falls

Due to the limitations of the monitoring data, it was only feasible to assess stormwater impacts for the City of Sioux Falls for TSS. Two methods were used to assess TSS for the City of Sioux Falls, the first being a mass balance approach, using FLUX model data, to determine the relative percent (contribution) of TSS loading to the Big Sioux River (R13) (see SUMMARY OF POLLUTANT LOADINGS BY SUBWATERSHED section) and the second method used the data from the Characterizations of Stormwater Runoff in Sioux Falls, South Dakota, 1995-96 report (USGS 1996).

To isolate the City of Sioux Falls relative contribution, the first method of mass balance used R11 (North Cliff Avenue), minus R09 (BSR at Hwy 38A), minus T23 (Skunk Creek), and minus T24 (Silver Creek) (See Figure 9) and the second method used the R11 total mean for TSS mass from Table 17 of the USGS report divided by the total TSS mass from the FLUX model, multiplied by 100 to determine the percent contribution from the vicinity of the City of Sioux Falls.

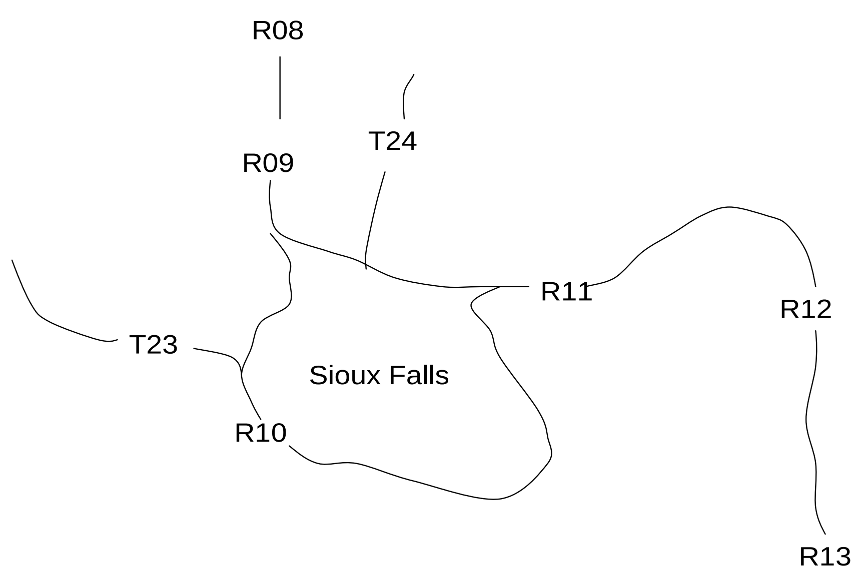


Figure 9. Sketch of the Sioux Falls Area and Monitoring Sites Used to Figure Stormwater Runoff

Brookings

To calculate the City of Brookings relative contribution for sediment, a mass balance approach using Site R2 (BSR @ Sinai Road), minus R03 (BSR at Hwy 77), minus T10 (Lake Campbell Outlet), and minus the bed and bank erosion estimate for 8.8 miles of the river (R02 to R03). The total amount area draining into this small subwatershed was divided into the sediment result in an export coefficient (lbs/acre). The export coefficient was multiplied by the city's drainage area resulting in the estimated contribution.

Contributions of TSS from stormwater runoff for the communities of Dell Rapids, and Flandreau were not calculated due to insufficient monitoring sites in those locations.

Non Point Sources

Agricultural Runoff

Agricultural runoff was taken into account when the Sediment Delivery Model calculated land use scenarios for TSS reductions, and when AGNPS was used to perform ratings on the feedlots in the study area. This information was then incorporated in the process of prioritizing watershed areas for fecal reduction.

Background Wildlife Contribution

As part of the background contribution of fecal coliform bacteria, wildlife was considered. A general estimate of wildlife fecal coliform bacteria loading was derived from assessing total deer contributions. Deer are the largest of the wild animals occupying the study area and factual information was readily available about this animal. Using 2002 deer population numbers (Personal Communication SDGFP) per square mile for Brookings, Moody, and Minnehaha counties estimations of deer per square mile were calculated. The five land management units (LMUs) used to calculate this contribution were chosen because each was an individual subwatershed with no influence from any other monitoring locations within the study area (See the Results Section).

The average deer per acre was multiplied by the acres given for each of five land management units (T19, T20, T22, T25, and T26) giving number of deer per LMU.

$$\text{deer/acre} \times \text{LMU acres} = \text{deer/LMU}$$

Then the number of deer per LMU was multiplied by the number of days monitored and then multiplied by the CFU/deer/day (MPCA 2002) to calculate total CFU's per LMU from deer.

$$\text{deer/LMU} \times \text{\# monitoring days} \times \text{CFU/deer/day} = \text{CFU's per LMU (from deer)}$$

To determine the percent deer contribution of fecal coliform bacteria, CFU's per LMU per deer were divided by the total CFU's monitored, multiplied by 100.

$$[\text{CFU's per LMU} \div \text{CFU's monitored}] \times 100 = \text{\% deer contribution of fecal coliform bacteria}$$

Failing Septic Systems Contribution

As part of the background contribution from fecal coliform bacteria, rural households were assessed for their contribution of the total fecal concentration in the watershed.

Using the Census 2000 Housing Units (US Census Bureau 2000) housing unit numbers per township for LMU T19, T20, T22, T25, and T26 were calculated and averaged. These particular LMU's were chosen because they represented individual subwatersheds, with no influence from other monitoring sites within the study area. See the results section.

The average number of people per household (MPCA 2002) was multiplied by the number of households for the five land management units, giving a total number of people.

average number of people per household × # of households = total number of people

Then the total number of people per LMU was multiplied by the number of days monitored and then multiplied by the CFU/person/day to calculate total CFU's per LMU from people.

total number of people per LMU × # monitoring days ×CFU/people/day = CFU's per LMU (from people)

To determine the percent septic contribution of fecal coliform bacteria, CFU's per LMU per person were divided by the total CFU's monitored, multiplied by 100.

[CFU's per LMU ÷ CFU's monitored] × 100 = % septic system contribution of fecal coliform bacteria

Modeling

The strategy for selecting modeling and assessment techniques was based on the need to:

1) balance the cost of modeling intensity with the need to cover a broad geographic area in a timely manner,
2) link the transport of total suspended solids (TSS) with watershed processes and land uses,
3) link the transport of fecal coliform bacteria with feedlot density, proximity, and ratings, and land uses, and thus
4) generate key information that integrates the relationship of cumulative effects and watershed health (indices of biological integrity) with the choices and consequences of human decisions in watershed protection and restoration.

These needs conform to the advantages of performing an assessment on a large scale (Barbour et al. 1999). Specific advantages include being able to address cumulative effects by accounting for large-scale watershed processes and how this ability can be used to guide management approaches.

Six basic modeling and assessment techniques that were used are described below. Each technique generates an independent set of information (Table 26). The IPI and IBI assessment techniques have previously been described. This section will focus on the four models used to assess water quality in the study area.

Table 26. Modeling and Assessment Techniques and Outputs Used for the CBSRWAP

Modeling Technique	Outputs
FLUX Model	Loadings for WQ Parameters Concentrations for WQ Parameters

Sediment Delivery Model (SDM)	Sediment Yield
Table 26 cont.	
	Land Cover Types Land Use Scenarios
Flow Duration Interval Zones	Hydrologic Condition Targets and Loads % reduction for fecal coliform bacteria
AGNPS - Feedlot Rating Model	Total P & N, chemical oxygen demand (COD), and a feedlot rating

Assessment Technique	Outputs
Physical Assessment	Index of Physical Integrity (IPI)
Biological Assessment	Fish Index of Biological Integrity (IBI) Macroinvertebrate Index of Biological Integrity IBI)

FLUX Model

Total nutrient and sediment loads were calculated with the use of the Army Corps of Engineers Eutrophication Model known as FLUX (Walker 1999). FLUX uses individual sample data in correlation with daily discharges to develop six loading calculations. For each monitoring site, loadings of total suspended solids, as well as water quality parameters not identified as impairing water quality, were calculated with the model. For fecal coliform bacteria, concentrations were calculated. The FLUX model uses data obtained from 1) grab-sample water quality concentrations with an instantaneous flow and 2) continuous flow records. Loadings and concentrations were calculated by month and stratified into low and high flows. Coefficients of variation (CV) were used to determine what method of calculation was appropriate for each parameter at each site (See Appendix T). Each water quality parameter was saved by site as daily, monthly and yearly concentrations and loadings. See Appendix U for monthly concentrations by site, and Appendix V for monthly loadings by site.

Water quality, sampled according to Stueven et al. (2000), was analyzed at South Dakota State University, Water Quality Laboratory. Water quality analyses provided concentrations for a standard suite of parameters previously mentioned. Continuous streamflow records for tributary sites were derived using stage records and stage-discharge curves (See Appendix E). Continuous streamflow records for river sites located at USGS monitoring sites were obtained, and streamflow records for river sites between USGS monitoring sites were derived using interpolation methods (Gordon 1992).

Sediment Delivery Model (SDM)

A sediment delivery model (See Appendix W) calculates sediment yield from a watershed in tons per year for a given rainfall event (i.e. 2 year – 24 hour) using the modified soil loss equation in ArcView. In the process, runoff (acre-ft) and peak flow rate (cubic feet per second) are calculated. This model was developed by Calvin Wolter of the Iowa Department of Natural Resources, Bureau of Geology. The actual modeling was contracted to the GAP office in the Department of Wildlife and Fisheries Sciences, South Dakota State University. The contract is provided in Appendix X.

Sediment yields (tons) were estimated for more than 50 land units using a GIS-based, sediment delivery model to identify land units in the central Big Sioux River watershed delivering high sediment loads to receiving tributaries and river segments. Due to the size of the study area and logistical constraints, this modeling approach efficiently used the lowest level of land use detail that was readily obtainable (i.e., 30 m^2). Expertise and technical advice was obtained from Natural Resource Conservation Service personnel familiar with soils and the universal soil loss equations. Minnesota portions of the watershed were not included because SURGO soils data required for modeling were not available.

Areas in the watershed were delineated into low (LEP), moderate (MEP), or high erosion potential (HEP) according to length-slope data obtained from digital elevation models. Break points in length-slope data that separate low, moderate, and high erosion potential were selected in consultation with NRCS staff. Basic land cover types were delineated using Landsat 7 imagery from two time periods (Spring and Fall). Based on erosion potential and cover types, a cropping factor (Cf) was assigned to the GIS grid. For cover types with low and moderate erosion potential, a standardized Cf was assigned. For cover types with high erosion potential, tillage type was assessed through the conservation districts' staff and field visits. Tillage types were identified as no tillage, minimum tillage, and conventional tillage. Based on these tillage practices, a standardized Cf was assigned. For cover types with high erosion, conservation practices were identified as contour farming, or contour farming with terraces. Based on conservation practice, assumptions were made and a standardized practice factor (Pf) was assigned. Cfs and Pfs were selected based on the most likely conditions or average scenarios (See Table 27). A preliminary examination of erosion potential and land cover types revealed substantial areas of moderate and high erosion potential cropland within the landscape surrounding portions of the river as impaired by TSS.

Table 27. Cf and Pf Factors Used with the SDM

	No Till		**Minimum Till**		**Conventional Till**	
	HEP	MEP	HEP	MEP	HEP	MEP
Pf - Contour Buffer Strip	0.47	0.50	0.43	0.45	0.41	0.45
Pf - Terrace	0.32	0.35	0.24	0.23	0.18	0.18
Cf – 0% of Slope in Grass	0.06	0.06	0.21	0.21	0.26	0.26
Cf – 10% of Slope in Grass	0.05	0.05	0.19	0.19	0.23	0.23

Crop management factors were assigned according to three classes of tillage types: no tillage, minimum tillage, and conventional tillage. Information was obtained from the Minnehaha Conservation districts' staff. No tillage assumed a residue cover of > 50 percent. Minimum tillage included several conservation tillage practices and assumed a residue cover of 15 to 50 percent, and conventional tillage assumed residue coverage of < 15 percent.

Practice factors were assigned to two classes: terraced and non-terraced. Information on terraces was gathered from the moderate to high erosion potential cropland in Minnehaha County by road survey. For each quarter section, the presence of terraces was noted on a map, which was later transferred to a GIS database. An assumption was that the presence of terraces also signified contour farming, and the absence of terraces signified no contour farming. Field observations suggested that this assumption was largely true.

Land use information was delineated as the area and percentage of cover types within each land unit using Landsat imagery in geographic information systems. If more than one land unit comprised the watershed area draining to a monitoring site, then the areas and percentages were summed for each cover type within that watershed area. Percentages of landuse types above each of the 33 monitoring stations were determined. These cover types are described in the sediment delivery model.

Stream buffer condition was similarly quantified using two buffer widths: 10 m and 30 m. Within these buffers, land cover types were quantified as the area and percentage by stream order using Strahler stream order schematics (See Figure 10). First through third order streams were combined, because these streams comprised the vast majority of the drainage density in the watersheds and are the immediate recipients of overland transport of energy and material resources.

Historical rainfall data was gathered selected rainfall gaging stations for 2 year, 5 year, 10 year, and 20 year, 24 hour, events (See Appendix Y). Sediment yields were then predicted. A series of scenarios incorporating changes in land use that had the highest potential for reducing sediment were selected. Land use changes include tillage practices, conservation practices, and buffer management. These scenarios produced information on sediment yield for 46 monitoring sites (33 tributaries and 13 river sites) (See Appendix Z).

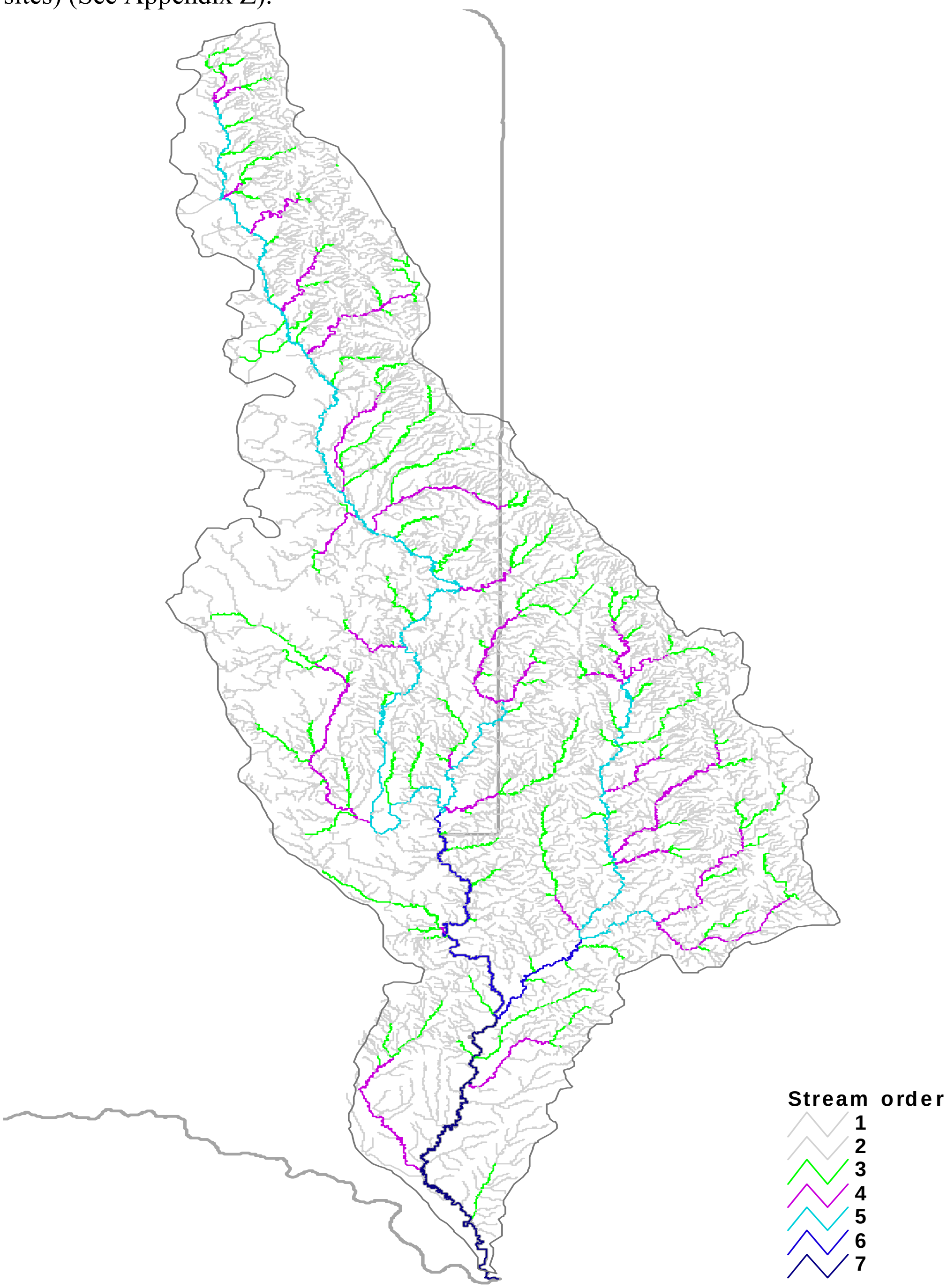


Figure 10. Big Sioux Basin Stream Orders

Flow Duration Intervals and Hydrologic Zones

America's Clean Water Foundation was consulted for ideas on calculating fecal coliform bacteria reductions with the limited data set that was collected. It was suggested that flow duration intervals using flow duration curve zones would meet the requirements for this report (Cleland 2003). This method calculates fecal coliform bacteria the same way the FLUX model does, (concentration) x (flow), except this method uses zones based on hydrologic conditions and the medians of the fecal coliform bacteria grab sample data. By defining hydrologic conditions, specific restoration efforts can be targeted. Typically five hydrologic conditions are used: (1) High Flows (0-10%), (2) Moist Conditions (10-40%), (3) Mid-Range Flows (40-60%), (4) Dry Conditions (60-90%), and (5) Low Flows (90-100%) (Figure 11). For example, if several samples exceeded the target load during dry conditions, restoration efforts may be targeted at instream livestock, riparian areas, or discharges from industries. This is further defined and explained in the Future Activity Recommendations Section.

Two major accumulations of data were used to calculate reductions: (1) discharge data, and (2) water quality samples. Appendix AA lists the years of record used for the construction of the flow duration interval graphs. Figure 11 is an example of a flow duration interval, separated into zones, with seasonal fecal grab samples plotted. Seasonal months include May, June, July, August, and September.

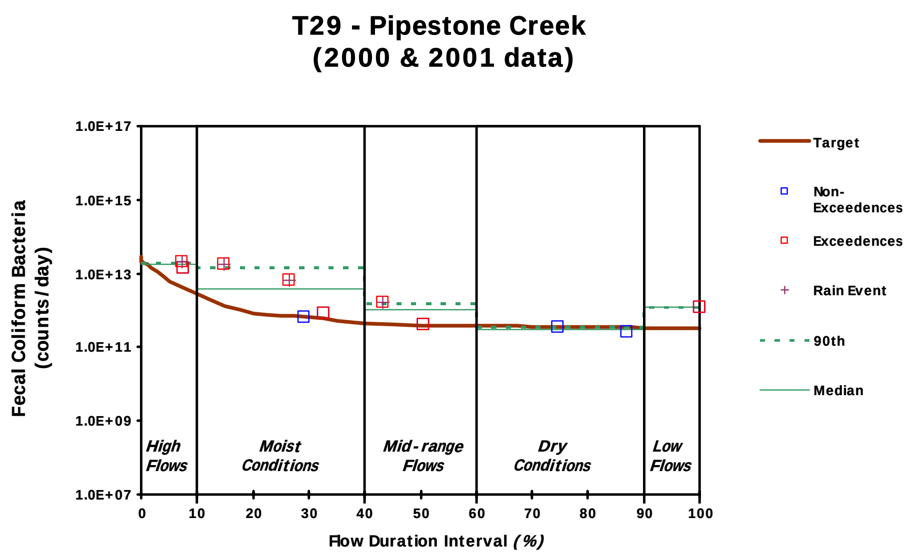


Figure 11. Example Flow Duration Interval with Zones and Plotted Grab Samples

The target line was graphed along 11 points using percentiles of the target load at matching flows. Similarly, grab samples were plotted using the instantaneous flow at the time the sample was taken. Medians and 90th percentiles were calculated, per zone, for grab sample data. All fecal coliform samples shown in the graph were collected from May through September, i.e. the recreation season. Rain events are indicated with an '+' and those samples exceeding the water quality standard or target line are outlined in red.

To find the percent reduction per hydrologic condition, the median of the allowable load within a hydrologic zone (target) was divided by the median of the sampled load at that particular hydrologic condition (site value) and then subtracted from 100.

$$100 - (\text{Target} \div \text{Site Value} \times 100) = \%\ \text{reduction}$$

To find the reduction with a 10 percent margin of safety applied the following equation was used:

$$100 - [(\text{Target} \div 1.1) \div (\text{Site Value}) \times 100] = \%\text{ reduction with MOS}$$

Table 28 shows an example of these calculations. Reduction calculation tables for all the monitoring sites can be found in Appendix BB. When considering management options for fecal coliform bacteria reductions, these tables will be useful in targeting those hydrologic conditions exceeding their allowable loads.

Table 28 also shows reductions for Site T28 and T29 as well as the outcome when the data was merged from both sites. Figures 11a through 11c also show the load duration curve for the individual sites as well as the curve after both Sites T28 and T29 have been merged.

Table 28. Sample of Fecal Coliform Bacteria Reduction Calculation Steps before Site T28 and T29 (Pipestone Creek) and after the sites were merged.

Site T28	Median	High Flow (0-10)	Moist Conditions (10-40)	Mid-Range Flows (40-60)	Low Flows (60-90)	Dry Conditions (90-100)
	Median Concentration (counts/day)	4.77E+10	1.24E+11	3.79E+10	9.56E+10	4.29E+10
X	Flow Median (cfs)	381.38	48.90	12.64	8.20	4.82
=	Existing	1.82E+13	6.05E+12	4.79E+11	7.84E+11	2.07E+11
	Target Load (at 400 cfu/100mL)	3.76E+12	4.79E+11	1.25E+11	8.08E+10	4.78E+10
	% Reduction w/MOS	81	93	76	91	79
	Number of Samples	1	5	2	2	1
Note: units are counts/day						

Site T29	Median	High Flow (0-10)	Moist Conditions (10-40)	Mid-Range Flows (40-60)	Low Flows (60-90)	Dry Conditions (90-100)
	Median Concentration (counts/day)	2.85E+10	5.33E+10	2.57E+10	8.53E+09	3.66E+10
X	Flow Median (cfs)	625.12	71.72	39.74	36.48	33.57
=	Existing	1.78E+13	3.82E+12	1.02E+12	3.11E+11	1.23E+12
	Target Load (at 400 cfu/100mL)	6.12E+12	7.02E+11	3.89E+11	3.57E+11	3.29E+11
	% Reduction w/MOS	69	83	65	0	76
	Number of Samples	2	4	2	2	1
Note: units are counts/day						

Sites merged	Median	High/Moist (0-40)	Mid-Range (40-60)	Low/Dry (60-100)
	Median Concentration (counts/day)	8.05E+10	8.42E+09	7.06E+10
X	Flow Median (cfs)	75.20	36.92	11.29
=	Existing	6.05E+12	3.11E+11	7.97E+11
	Target Load (at 400 cfu/100mL)	7.36E+11	3.61E+11	1.10E+11
	% Reduction w/MOS	89	0	87
	Number of Samples	13	2	7
Note: units are counts/day				

Because long term flow data was unavailable for most of the Big Sioux tributaries, flow information from sites located on the same waterbody were merged. The example used to explain this process is Pipestone Creek. Sites T28 and T29 were separated by approximately 24 stream miles but all 11 samples per site were sampled on the same dates (n=22). After reviewing the information a load duration curve was developed by merging flow data from both sites. Instead of 345 daily flows there were 690. Sample data was also combined. The reductions were calculated from median concentrations and median flow from the new flowzones developed for the combined load duration curve (Table 28).

This method allowed the data from the entire segment to be used to determine impairment status and reductions rather than a single downstream monitoring station. In this example, the number of samples within each flowzone was increased as is shown in Table 28. One or two samples were collected within the high flowzone of Sites T28 and T29, respectively. When sites were combined and flowzones expanded from 0-10% to 0-40% thirteen samples were used to calculate the median and corresponding reductions.

Although the mid-range flows show no reduction is required, the reductions needed to achieve full support status are significant in both high/moist conditions (0-40%) and dry conditions (60-90%). Best Management Practices will be used targeting both high and low flow conditions.

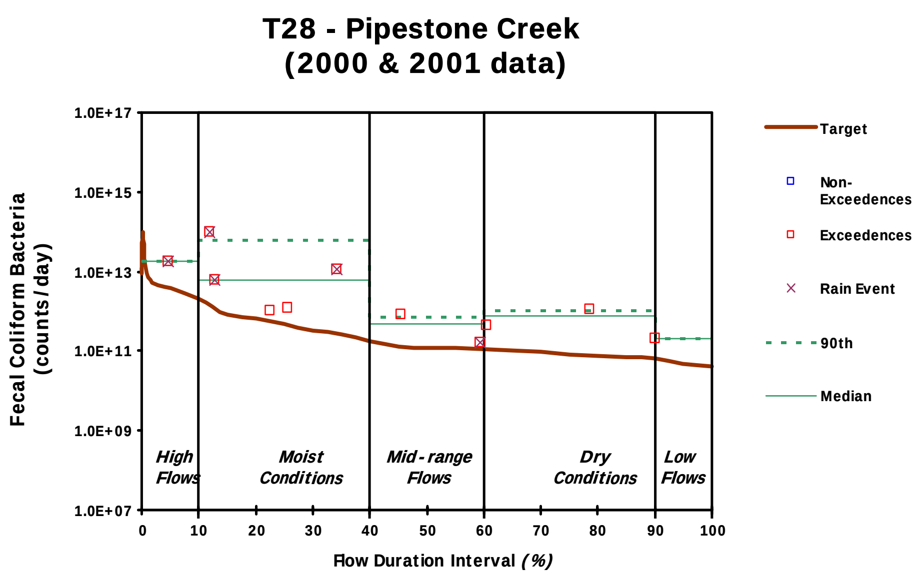


Figure 11a. Load Duration Curve for Pipestone Creek, Site T28.

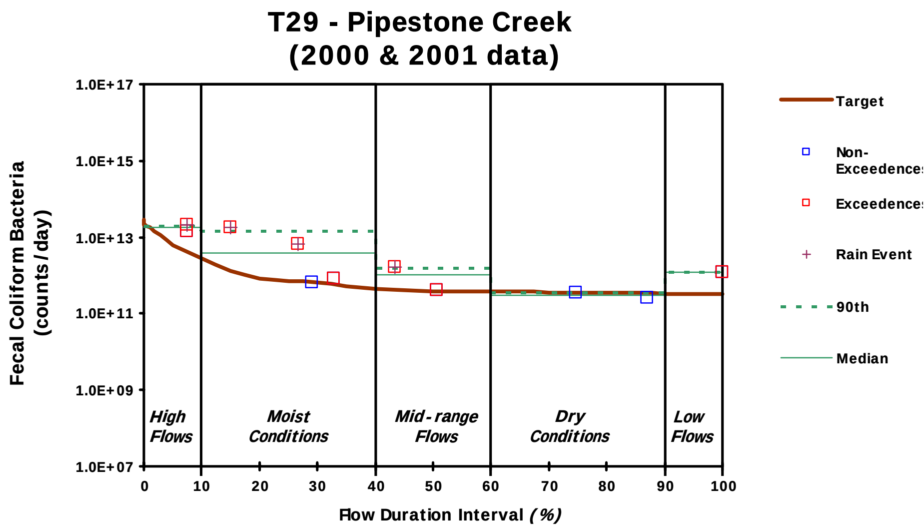


Figure 11b. Load Duration Curve for Pipestone Creek, Site T29.

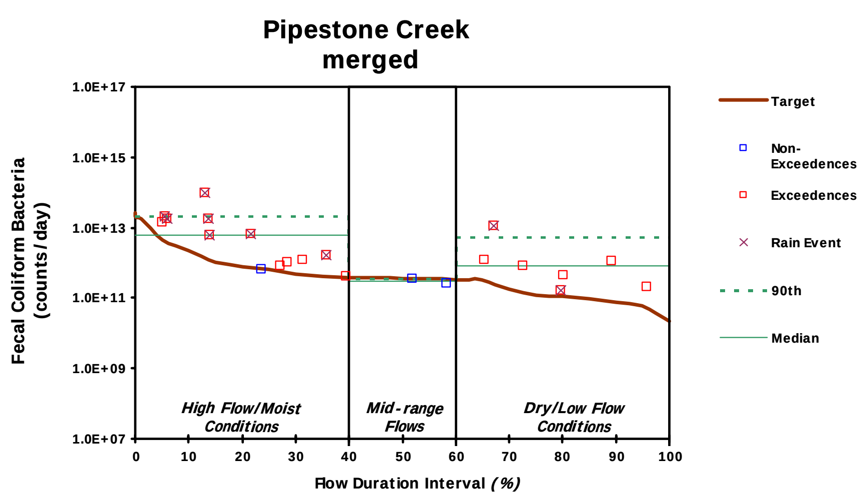


Figure 11c. Load Duration Curve for Pipestone Creek, Site T28 and T29 data merged.

AGNPS Feedlot Model

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source pollutant loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze feedlots and their pollution potential.

Watersheds dominated by agricultural land uses, pasturing cattle in stream drainages, runoff from manure application, and runoff from concentrated animal feeding operations can influence fecal coliform bacteria concentrations. The AGNPS feedlot assessment assumed the probable sources of fecal coliform bacteria loadings were related to agricultural land use (upland and riparian), use of streams for stock watering, and animal feeding operations.

The methods used in the CBSRWA to determine loadings and reductions of fecal coliform bacteria, could serve as an integrated measure of runoff from feedlots and land uses. Density of feedlots in a watershed upstream from a monitoring site provided a measure of source frequency. A mean of individual feedlot scores weighted by proximity to receiving water monitoring site provided an indicator of potential input from all feedlots. Upland and riparian land uses provide an indicator of the degree of potential land surface sources available to pasturing of livestock. A complete methodology report can be found in Appendix CC.

RESULTS

WATER QUALITY MONITORING

The data was evaluated based on the specific criteria that the DENR developed for listing water bodies in the 2006 South Dakota 303(d) Waterbody List. The EPA approved listing criteria used by the state of South Dakota during the assessment, to determine if a waterbody is meeting its beneficial uses, is contained in the following paragraph. It should be noted that EPA guidance, in reference to TMDL targets, are based on the acute criteria of any one sample, which was used in establishing targets for the TMDLs of this assessment.

Use support was based on the frequency of exceedences of water quality standards (if applicable) for the following chemical and field parameters. A stream segment with only a slight exceedence (10 percent or less violations for each parameter) is considered to meet water quality criteria for that parameter. The EPA established the following general criteria in the 1992 305(b) Report Guidelines (SDDENR 2000) suitable for determining use support of monitored streams.

Fully supporting	$\leq$ 10 % of samples violate standards
Not supporting	> 10 % of samples violate standards

This general criteria is based on having 20 or more samples for a monitoring location. Many of the monitoring sites were sampled less than 20 times. For those monitoring sites with less than 20 samples but greater than 10, the following criteria will apply:

Fully supporting	$\leq$ 25 % samples violate standards
Not supporting	> 25 % of samples violate standards

In addition, the sample threshold was increased to 100% if five samples were used to determine full or nonsupport for conventional parameters, i.e. dissolved oxygen, total suspended solids, pH, and water temperature.

Use support assessment for fishable use (fish life propagation) primarily involved monitoring levels of the following major parameters: dissolved oxygen, unionized ammonia, water temperature, pH, and suspended solids. Use support for swimmable uses and limited contact recreation involved monitoring the levels fecal coliform bacteria (May 1 – September 30) and dissolved oxygen. If more than one beneficial use is assigned for the same parameter (i.e. fecal coliform bacteria) at a particular monitoring site, the more stringent criteria will apply. The use support for monitoring sites will be discussed further in the Assessment Section. The results for the following parameters are summarized below for all the tributary and river sites. See Appendix DD for detailed information about means, minimums, maximums, medians, percent violations, and use support of each monitoring site and parameter.

Chemical Parameters

Fecal Coliform Bacteria

Fecal coliform bacteria ranged from a minimum of 10 cfu/100mL (T03-Six Mile Creek) to a maximum of 210,000 cfu/100mL (T19-Colton Creek) for all tributary sites T01 through T33 (See Figure 12). The lowest mean was 534 cfu/100mL (T03) and the highest mean was 28,555 cfu/100mL (T19). The lowest median of 160 cfu/100mL was at site T17 and the highest median of 4,200 cfu/100mL was at site T25.

Fecal coliform bacteria ranged from non detect (R05- BSR near Flandreau) to a maximum of 117,000 cfu/100ml (R13-BSR near Gitchie Manitou) for all river sites R01 through R13 (See Figure 12) The lowest mean was 296 cfu/100mL (R01) and the highest mean was 13,426 cfu/100mL (R13). The lowest median of 100 cfu/100mL was at site R05 and the highest median of 520 cfu/100mL was at site R10.

A single grab sample daily maximum of 400 cfu/100mL was used to determine the percent violations and assess for the beneficial use support of (7) Immersion Recreation for tributary sites T28, T29, T30, T31 and river sites R08-R13. A single grab sample daily maximum of 2000 cfu/100mL was used to determine the percent violations and assess for the beneficial use support of (8) Limited Contact Recreation for tributary site T01-T06, T09, T11-T14, T17, T18, T21, T23, T24, T32, T33 and river sites R01-R07. Using this criterion, tributary sites T02, T04, T05, T11-T14, T17, T18, T23, T28-T33, and rivers sites R07-R13 are not supporting for this parameter. Sites that are fully supporting include T01, T03, T06, T09, T21, T24, and R01-R06. Based on the existing standards for fecal coliform bacteria, tributary sites T07, T08, T10, T15, T16, T19, T20, T22, T25, T26, T27 are not assigned a beneficial use.

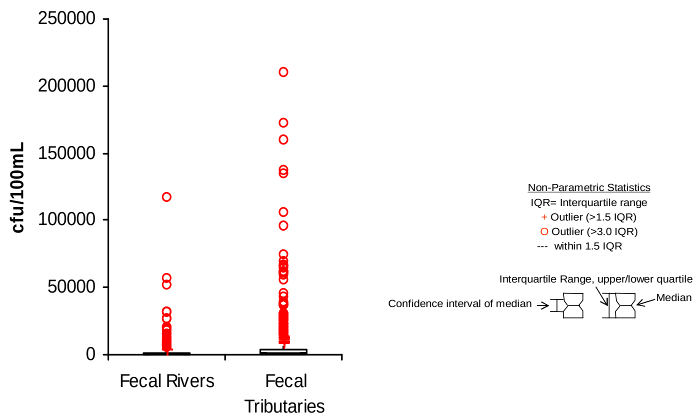


Figure 12. Box and Whisker Plot of Fecal Coliform Bacteria for River and Tributary Sites

Total Solids

Total solids ranged from a minimum of 100 mg/L (T26-West Pipestone Creek) to a maximum of 1,862 mg/L (T15-Buffalo Creek) for all tributary sites T01 through T33 (See Figure 13). The lowest mean was 404 mg/L (T07) and the highest mean was 1,388 mg/L (T10). The lowest median of 398 mg/L was at site T07 and the highest median of 1,358 mg/L was at site T10.

Total solids ranged from a minimum of 284 mg/L (R01-BSR near Brookings) to a maximum 1,569 mg/L (R13-BSR near Gitchie Manitou) for all river sites R01 through R13 (See Figure 13). The lowest mean was 683 mg/L (R06) and the highest mean was 865 mg/L (R03). The lowest median of 650 mg/L was at site R06 and the highest median of 844 mg/L was at site R03.

There is no standard or assigned beneficial use for this parameter.

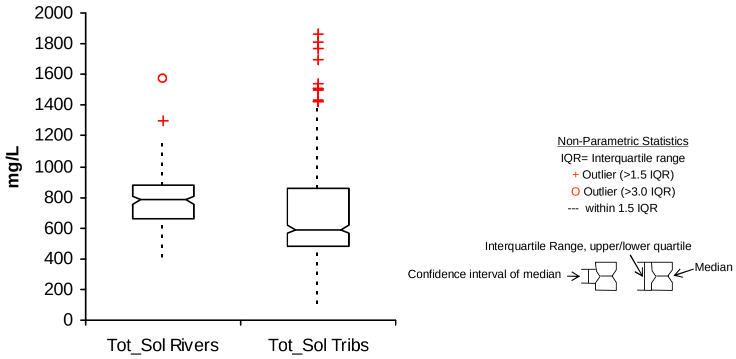


Figure 13. Box and Whisker Plot of Total Solids for River and Tributary Sites

Total Suspended Solids

Total suspended solids ranged from a minimum of one mg/L (T24-Silver Creek) to a maximum of 1,580 mg/L (T32-Beaver Creek) for all tributary sites T01 through T33 (See Figure 14). The lowest mean was 19 mg/L (T17) and the highest mean was 286 mg/L (T32). The lowest median of 5 mg/L was at Site T24 and the highest median of 89 mg/L was at site T30.

Total suspended solids ranged from a non detect (R05-BSR near Flandreau) to a maximum of 1,264 mg/L (R13-BSR near Gitchie Manitou) for all river sites R01 through R13 (See Figure 14). The lowest mean was 78 mg/L (R01) and the highest mean was 228 mg/L (R13). The lowest median of 54 mg/L was at site R03 and the highest median of 111 mg/L was at site R13.

A single grab sample daily maximum of 158 mg/L was used to determine the percent violations and assess for the beneficial use support of (5) Warm Water Semi-permanent Fish Life Propagation for tributary sites T28-T31 and river sites R01-R13. A single grab sample daily maximum of 263 mg/L was used to determine the percent violations and assess for the beneficial use support of (6) Warm Water Marginal Fish Life Propagation for tributary sites T01-T06, T09, T11-T14, T17, T18, T21, T23, T24, T32, and T33. All tributary sites assigned this criteria are fully supporting of this parameter except for sites T32 and T33 which are not supporting. Based on the existing standard for total suspended solids, tributary sites T07, T08, T10, T15, T16, T19, T20, T22, T25, T26, T27 are not assigned a beneficial use. All river sites are not supporting of this parameter with the exception of R06, R07, R08, and R10 which are fully supporting.

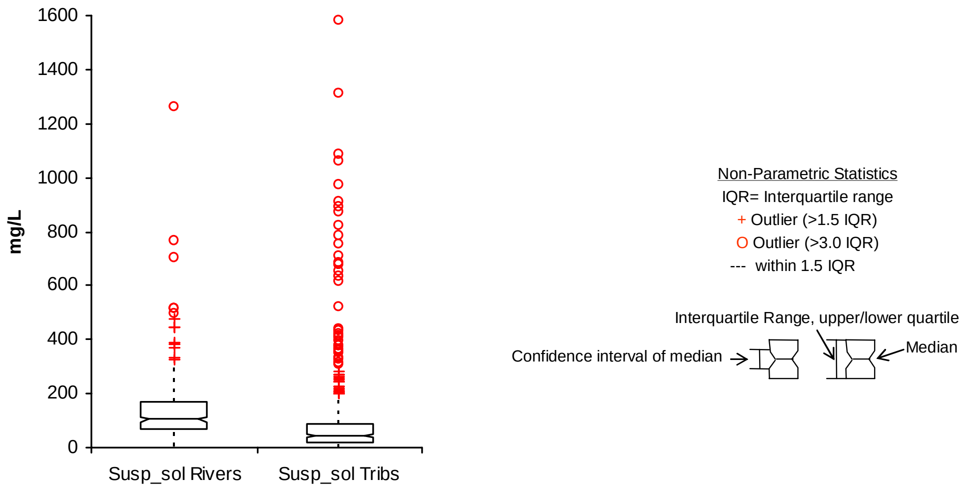


Figure 14. Box and Whisker Plot of TSS for River and Tributary Sites

Total Dissolved Solids

TDS ranged from a minimum of 75 mg/L (T15-North Buffalo Creek) to a maximum of 1,752 mg/L (T26-West Pipestone Creek) for all tributary sites T01 through T33 (See Figure 15). The lowest mean was 327 mg/L (T27) and the highest mean was 1,333 mg/L (T10). The lowest median of 342 mg/L was at site T31 and the highest median of 1,296 mg/L at site T10.

TDS ranged from a minimum of 200 mg/L (R09-BSR at Hwy 38A) to a maximum of 1,252 mg/L (R08-BSR at Dell Rapids) for all river sites R01 through R13 (See Figure 15). The lowest mean was 557 mg/L (R09) and the highest mean was 723 mg/L (R03). The lowest median of 552 mg/L was at site R09 and the highest median of 768 mg/L was at site R10.

A single grab sample daily maximum of 4,375 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife, Propagation, Recreation and Stock Watering for all tributary sites and river sites R01-R07. A single grab sample daily maximum of 1,750 mg/L was used to determine the percent violations and assess for the beneficial use support of (1) Domestic Water Supply for all river sites R08-R13. Using this criterion, all tributary sites T01 through T33 and all river sites R01 through R13 are fully supporting for this parameter.

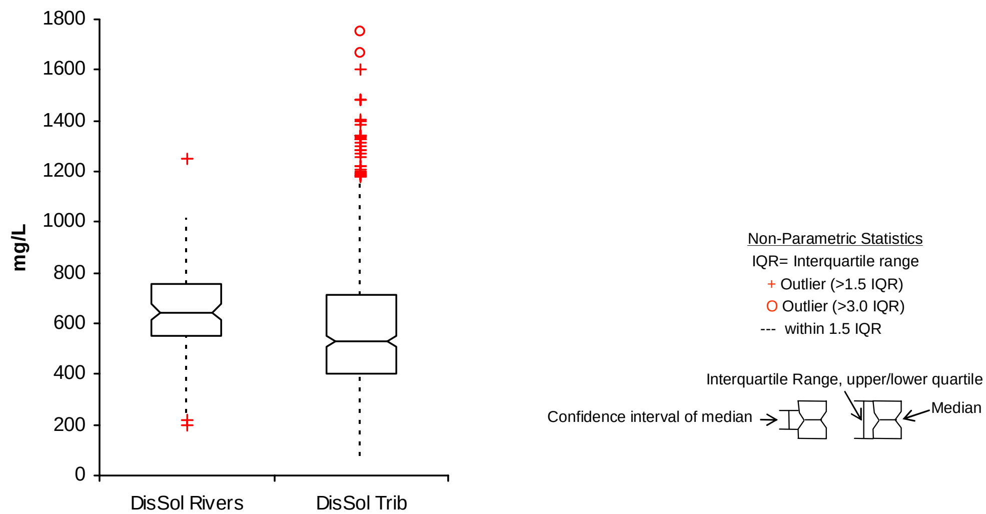


Figure 15. Box and Whisker Plot of Total Dissolved Solids for River and Tributary sites

Ammonia

Ammonia ranged from a non detect (T21-Skunk Creek) to a maximum of 5.948 mg/L (T10-Lake Campbell Outlet) for all tributary sites T01 through T33 (See Figure 16). The lowest mean was 0.092 mg/L (T01) and the highest mean was 2.121 mg/L (T10). The lowest median of 0.058 mg/L was at site T33 and the highest median of 1.672 mg/L was at site T10.

Ammonia ranged from a non detect (R05-BSR near Flandreau) to a maximum 1.001 mg/L (R09-BSR at Hwy 38A) for all river sites R01 through R13 (See Figure 16). The lowest mean was 0.045 mg/L (R03) and the highest mean was 0.221 mg/L (R13). The lowest median of 0.019 mg/L was at site R03 and the highest median of 0.140 mg/L was at site R11.

There is no standard or assigned beneficial use for this parameter.

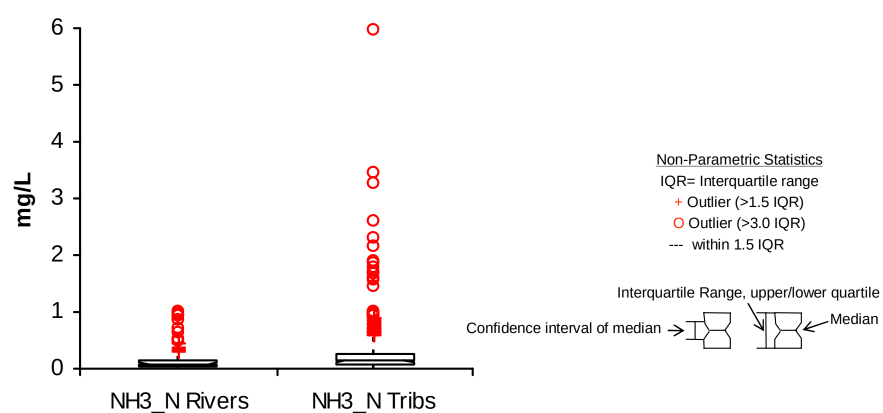


Figure 16. Box and Whisker Plot of Ammonia for River and Tributary Sites

Unionized Ammonia

Unionized ammonia concentration ranged from a non detect (numerous sites) to a maximum of 0.220 mg/L (T16-Buffalo Creek) for all tributary sites T01 through T33 (See Figure 17). The lowest mean concentration was 0.004 mg/L and the highest mean concentration was 0.032 mg/L (T16). The lowest median concentration of 0.003 mg/L occurred at several sites, and the highest median concentration of 0.023 mg/L was at site T10.

Unionized ammonia concentration ranged from a non detect (several sites) to a maximum of 0.040 mg/L (R08-BSR at Dell Rapids) for all river sites R01 through R13 (See Figure 17). The lowest mean concentration was 0.003 mg/L (R03) and the highest mean concentration was 0.010 mg/L at several sites. The lowest median concentration of 0.001 mg/L was at site R03 and the highest median concentration of 0.008 mg/L was at site R11.

A single grab sample daily maximum concentration of 0.070 mg/L was used to determine the percent violations and assess for the beneficial use support of (5) Warmwater Semi-permanent Fish Life Propagation for all river sites R01-R13 and tributary sites T28-T31. A single grab sample daily maximum concentration of 0.0875 mg/L was used to determine the percent violations and assess for the beneficial use support of (6) Warmwater Marginal Fish Life Propagation for tributary sites T01-T06, T09, T11-T14, T17, T18, T21, T23, T24, T32, and T33. All tributary sites and all river sites assigned this criterion are fully supporting of this parameter. Based on the existing standard for unionized ammonia, tributary sites T07, T08, T10, T15, T16, T19, T20, T22, T25, T26, and T27 are not assigned a beneficial use.

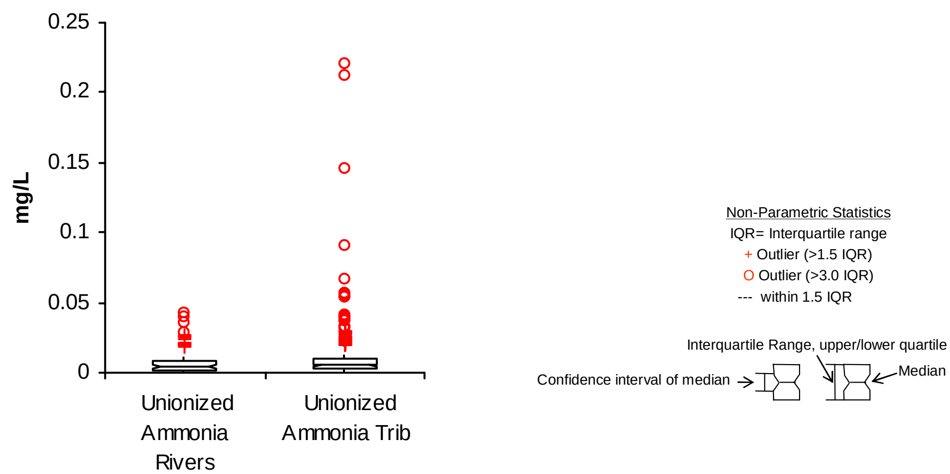


Figure 17. Box and Whisker Plot of Unionized Ammonia for River and Tributary Sites

Nitrate-Nitrite

Nitrate-nitrite ranged from a minimum of 0.015 mg/L (T02-North Deer Creek) to a maximum of 18.484 mg/L (T10-Lake Campbell Outlet) for all tributary sites T01 through T33 (See Figure 18). The lowest mean was 0.112 mg/L (T01) and the highest mean was 4.39 mg/L (T32). The lowest median of 0.052 mg/L at T01, and the highest median of 4.731 mg/L were at site T33.

Nitrate-nitrite ranged from a minimum of 0.007 mg/L (R02-BSR at Sinai Road) to a maximum of 14.968 mg/L (R12-BSR at Brandon) for all river sites R01 through R13 (See Figure 18). The lowest mean was

0.178 mg/L (R02) and the highest mean was 3.45 mg/L at R12. The lowest median of 0.088 mg/L was at site R02 and the highest median of 2.063 mg/L was at site R13.

A single grab sample daily maximum of 10 mg/L was used to determine the percent violations and assess for the beneficial use support of (1) Domestic Water Supply for all river sites R01-R13. A single grab sample daily maximum of 88 mg/L was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife Propagation, Recreation and Stock Watering for all tributary sites T01-T33. Using this criterion, all tributary sites T01-T33 and all river sites R01-R13 are fully supporting of this parameter.

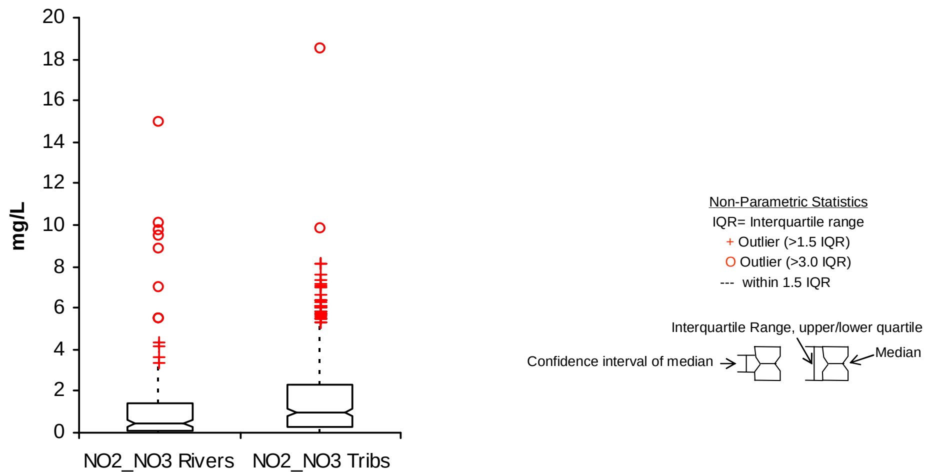


Figure 18. Box and Whisker Plot of Nitrate-Nitrite for River and Tributary Sites

Total Kjeldahl Nitrogen

TKN ranged from a minimum of 0.159 mg/L (T25-Slip-Up Creek) to a maximum of 15.718 mg/L (T10-Lake Campbell Outlet) for all tributary sites T01 through T33 (See Figure 19). The lowest mean was 1.128 mg/L (T01) and the highest mean was 5.443 mg/L (T10). The lowest median of 0.287 mg/L was at site T11 and the highest median of 3.238 mg/L was at site T10.

TKN ranged from a minimum of 0.846 mg/L (R10-BSR at Western Avenue) to a maximum 7.265 mg/L (R13-BSR near Gitchie Manitou) for all river sites R01 through R13 (See Figure 19). The lowest mean was 1.744 mg/L (R01) and the highest mean was 2.520 mg/L (R13). The lowest median of 1.589 mg/L was at site R01 and the highest median of 2.390 mg/L was at site R05.

There is no standard or assigned beneficial use for this parameter.

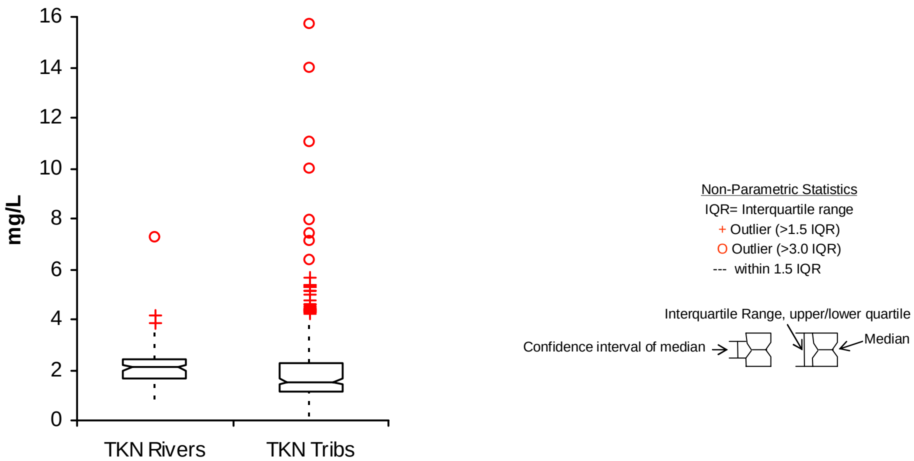


Figure 19. Box and Whisker Plot of Total Kjeldahl Nitrogen for River and Tributary Sites

Organic Nitrogen

Organic nitrogen ranged from a minimum of 0.364 mg/L (T08-Medary Creek) to a maximum of 10.721 mg/L (T10-Lake Campbell Outlet) for all tributary sites T01 through T33 (See Figure 20). The lowest mean was 0.954 mg/L (T09) and the highest mean was 3.322 mg/L (T10). The lowest median of 0.771 mg/L was at site T12 and the highest median of 2.572 mg/L was at site T16.

Organic nitrogen ranged from a minimum of 0.700 mg/L (R10-BSR at Western Avenue) to a maximum 6.561 mg/L (R13-BSR near Gitchie Manitou) for all river sites R01 through R13 (See Figure 20). The lowest mean was 1.667 mg/L (R10) and the highest mean was 2.300 mg/L (R13). The lowest median of 1.549 mg/L was at site R01 and the highest median of 2.532 mg/L was at site R05.

There is no standard or assigned beneficial use for this parameter.

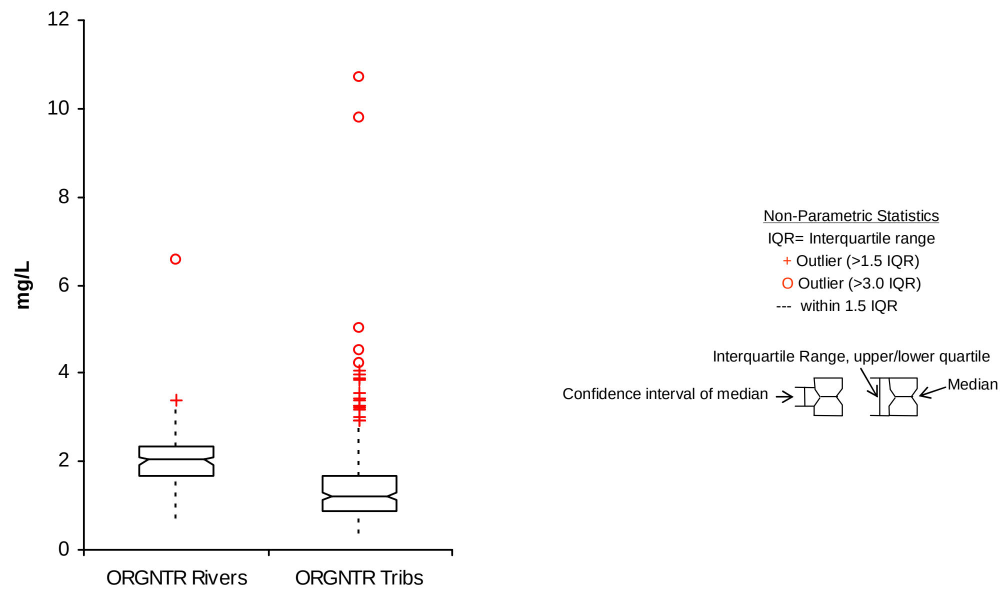


Figure 20. Box and Whisker Plot of Organic Nitrogen for River and Tributary Sites

Total Phosphorus

Total phosphorus ranged from a minimum of 0.012 mg/L (T11-Spring Creek) to a maximum of 3.968 mg/L (T33-Beaver Creek) for all tributary sites T01 through T33 (See Figure 21). The lowest mean was 0.110 mg/L (T07) and the highest mean was 0.742 mg/L (T32). The lowest median of 0.075 mg/L was at site T06 and the highest median of 0.710 mg/L was at site T26.

Total phosphorus ranged from a minimum of 0.047 mg/L (R01-BSR near Brookings) to a maximum 3.352 mg/L (R12-BSR at Brandon) for all river sites R01 through R13 (See Figure 21). The lowest mean was 0.324 mg/L (R01) and the highest mean was 0.987 mg/L (R12). The lowest median of 0.246 mg/L was at site R10 and the highest median of 0.726 mg/L was at site R11.

There is no standard or assigned beneficial use for this parameter. However, phosphorus is an essential nutrient for the production of crops from commercial fertilizers and livestock waste. It is also the primary nutrient for algae growth in lakes and streams. Since a standard for total phosphorus has not been established, data was compared to the ecoregion mean for phosphorus in Minnesota (Fandrei et al. 1988). In this report, according to Tables 3, Northern Glaciated Plains, and Table 7, Western Cornbelt Plains, the summer reference mean for total phosphorus is 0.25 mg/L and 0.30 mg/L, respectively.

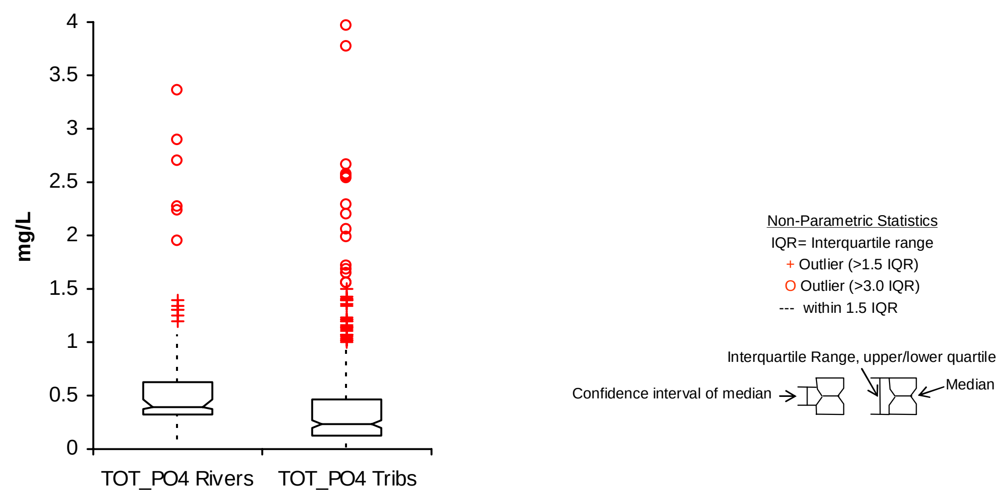


Figure 21. Box and Whisker Plot of Total Phosphorus for River and Tributary Sites.

Total Dissolved Phosphorus

Total dissolved phosphorus ranged from a minimum of 0.003 mg/L (T06-Deer Creek) to a maximum of 1.103 mg/L (T32-Beaver Creek) for all tributary sites T01 through T33 (See Figure 22). The lowest mean was 0.033 mg/L (T09) and the highest mean was 0.377 mg/L (T26). The lowest median of 0.025 mg/L was at site T09 and the highest median of 0.365 mg/L was at site T26.

Total dissolved phosphorus ranged from a minimum of 0.005 mg/L (R06-BSR at Egan) to a maximum 3.132 mg/L (R12-BSR at Brandon) for all river sites R01 through R13 (See Figure 22). The lowest mean was 0.073 mg/L (R06) and the highest mean was 0.654 mg/L (R12). The lowest median of 0.040 mg/L was at site R01 and the highest median of 0.351 mg/L was at site R11.

There is no standard or assigned beneficial use for this parameter.

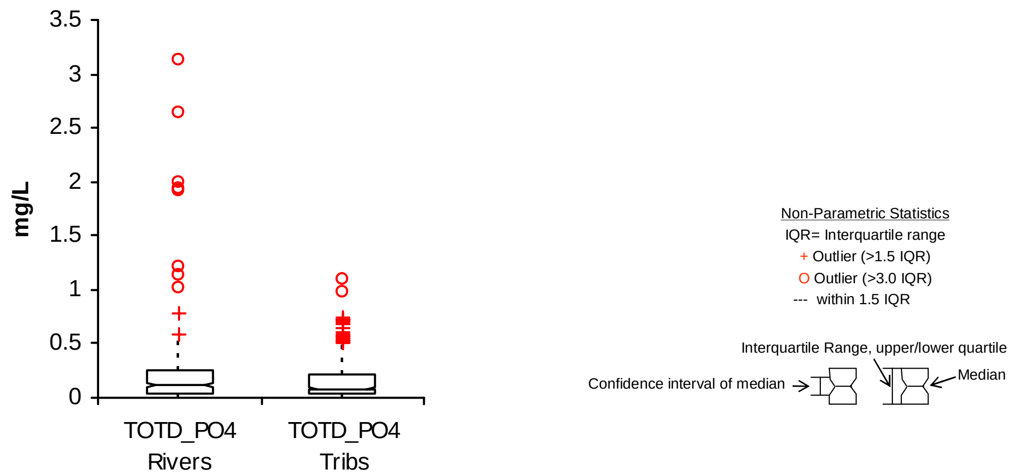


Figure 22. Box and Whisker Plot of Total Dissolved Phosphorus for River and Tributary Sites

Field Parameters

Dissolved Oxygen

Dissolved oxygen ranged from a minimum of 1.9 mg/L (T33-Beaver Creek) to a maximum of 20.0 mg/L (T10-Lake Campbell Outlet) for all tributary sites T01 through T33 (See Figure 23). The lowest mean was 6.1 mg/L (T26) and the highest mean was 10.7 mg/L (T21). The lowest median of 6.3 mg/L at T26, and the highest median of 10.8 mg/L were at site T21.

Dissolved oxygen ranged from a minimum of 2.8 mg/L (R11-BSR at North Cliff Avenue and R13-BSR near Gitchie Manitou) to a maximum of 16.6 mg/L (R03-BSR at Hwy 77) for all river sites R01 through R13 (See Figure 23). The lowest mean was 8.0 mg/L (R02) and the highest mean was 9.7 mg/L at R12. The lowest median of 7.4 mg/L was at site R05 and the highest median of 9.9 mg/L was at site R12.

A single grab sample daily maximum of ≥ 5 mg/L (most stringent) was used to determine the percent violations and assess for the beneficial use support of (5), (6), (7) and (8) for all river sites and tributary sites T01-T06, T09, T11-T14, T17, T18, T21, T23, and T28-T33.

Tributary sites assigned this criteria that are fully supporting of this parameter include T02-T04, T06, T09, T11-T14, T17, T18, T21, T23, T28-T30, and T33. River sites that are fully supporting of this parameter include R01-R08, R12, and R13. Although sites T01, T05, T31, and T32 exhibited violations of the dissolved oxygen standard (5 mg/L), the rate (%) did not exceed the 10%/25% rule used by DENR for impairment determination (pg. 50). Sites R9-R11 were impaired but will be reassessed to determine the specific source of the dissolved oxygen problem. Based on the existing standard for dissolved oxygen, tributary sites T07, T08, T10, T15, T16, T19, T20, T22, T24, T25, T26, and T27 are not assigned a beneficial use.

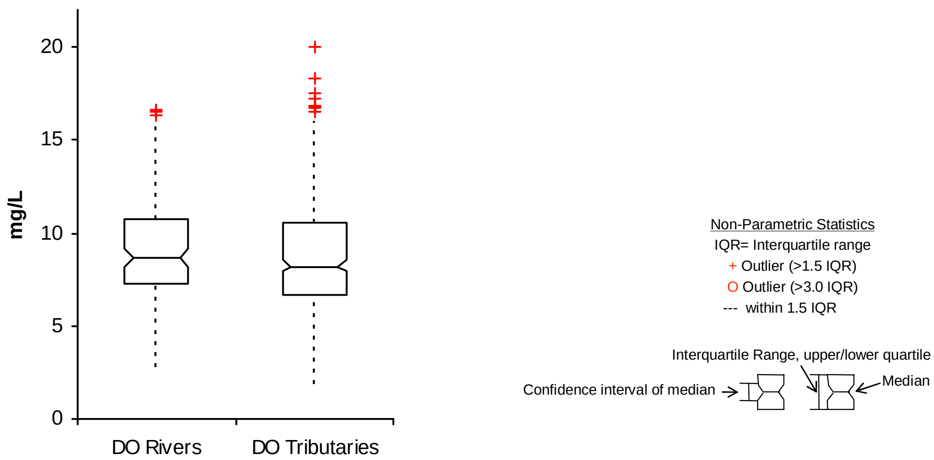


Figure 23. Box and Whisker Plot of Dissolved Oxygen for River and Tributary Sites

pH

pH ranged from a minimum of 6.9 (T03-Six Mile Creek and T22-Willow Creek) to a maximum of 10.9 (T16-Buffalo Creek) for all tributary sites T01 through T33 (See Figure 24). The lowest mean was 7.8 (T26) and the highest mean was 8.4 (T16). The lowest median of 7.8 was at Site T24, and the highest median of 8.3 was at several sites.

pH ranged from a minimum of 6.9 (R03-BSR at Hwy 77) to a maximum of 9.0 (R01-BSR near Brookings and R07-BSR at Trent) for all river sites R01 through R13 (See Figure 24). The lowest mean was 8.1 at several sites and the highest mean was 8.5 at R07. The lowest median of 8.1 was at several sites and the highest median of 8.5 was at site R07.

A single grab sample daily maximum of the most restrictive standard of 6.0-9.0 was used to determine the percent violations at and assess for the beneficial use support of (6) and (9) for tributary sites T01-T06, T09, T11-T14, T17, T18, T21, T23, T24, T32, and T33. Tributary sites assigned beneficial use (9) used the criteria of 6.0-9.5 include T07, T08, T10, T15, T16, T19, T20, T22, and T25-T27. A single grab sample daily maximum of the most restrictive standard of 6.5-9.0 was used to determine the percent violations at and assess for the beneficial use support of (1), (5), and (9) for all river sites R01-R13 and beneficial use support of (5) and (9) for tributaries T28-T31. Using this criterion, all tributary sites T01-T33 and all river sites R01-R13 are fully supporting of this parameter.

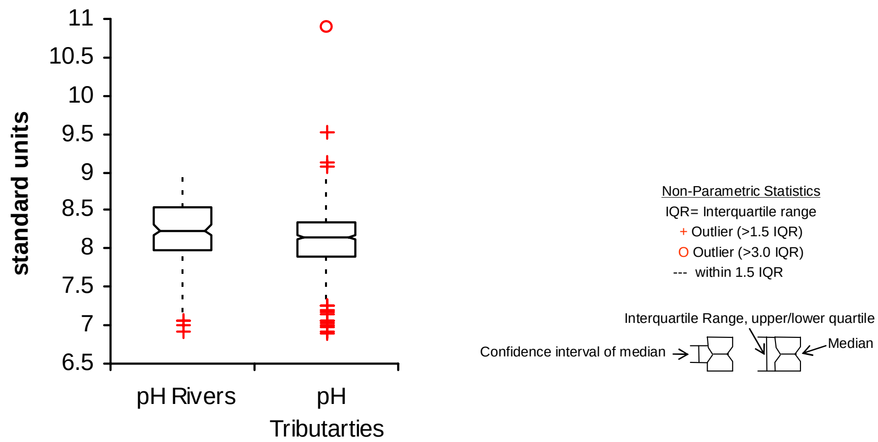


Figure 24. Box and Whisker Plot of pH for River and Tributary Sites

Air Temperature

Air temperature ranged from a minimum of -6.0° C (T09-Medary Creek) to a maximum of 40.0° C (T33-Beaver Creek) for all tributary sites T01 through T33 (See Figure 25). The lowest mean temperature was 15.7° C (T02) and the highest mean temperature was 23.8° C (T22). The lowest median temperature of 16.0° C was at site T10 and T28 and the highest median temperature of 25.0° C were at site T06.

Air temperature ranged from a minimum of -2.0° C (R02-BSR at Sinai Road and R06-BSR at Egan) to a maximum 35.0° C (R06-BSR at Egan and R07-BSR at Trent) for all river sites R01 through R13 (See Figure 25). The lowest mean temperature was 17.3° C (R02) and the highest mean temperature was 21.9° C (R07). The lowest median temperature of 18.0° C was at site R02 and the highest median temperature of 22.5° C was at site R10.

There is no standard or assigned beneficial use for this parameter.

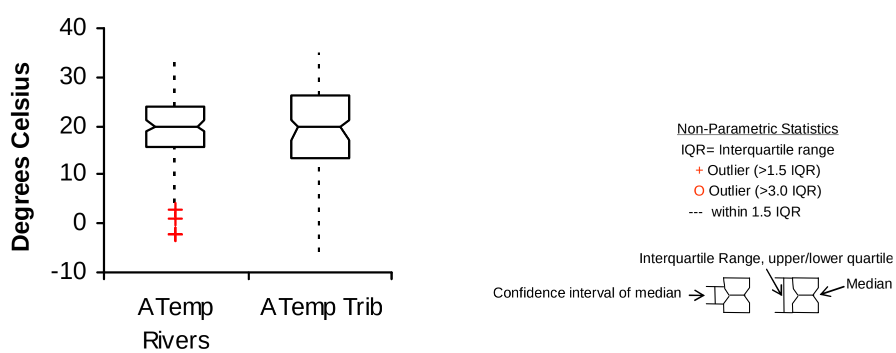


Figure 25. Box and Whisker Plot for Air Temperature for River and Tributary Sites

Water Temperature

Water temperature ranged from a minimum of 0.1° C (several sites) to a maximum of 34.8° C (T17-Brant Lake Outlet) for all tributary sites T01 through T33 (See Figure 26). The lowest mean temperature was 14.6° C (T25) and the highest mean temperature was 19.2° C (T14 and T22). The lowest median temperature of 14.4° C was at site T01, and the highest median temperature of 20.3° C was at T23.

Water temperature ranged from a minimum of 0.4^{o} C (R08-BSR at Dell Rapids and R09-BSR at Hwy 38A) to a maximum of 29.7^{o} C (R04-BSR at Brookings) for all river sites R01 through R13 (See Figure 26). The lowest mean temperature was 15.1^{o} C at R02 and the highest mean temperature was 19.7^{o} C at R03. The lowest median temperature of 13.1^{o} C at R02 and the highest median temperature of 22.2^{o} C were at site R03.

A single grab sample daily maximum temperature of 32.2^{o} C was used to determine the percent violations and assess for the beneficial use support of (5) for all of the river sites and tributary sites T28-T31. A single grab sample daily maximum of 32.2^{o} C was used to determine the percent violations and assess for the beneficial use support of (6) for tributary sites T01-T06, T09, T11-T14, T17, T18, T21, T23, T24, T32, and T33. All tributary sites and all river sites using this criterion are fully supporting of this parameter. Based on the existing standard for water temperature, tributary sites T07, T08, T10, T15, T16, T19, T20, T22, and T25-T27 are not assigned a beneficial use or standard.

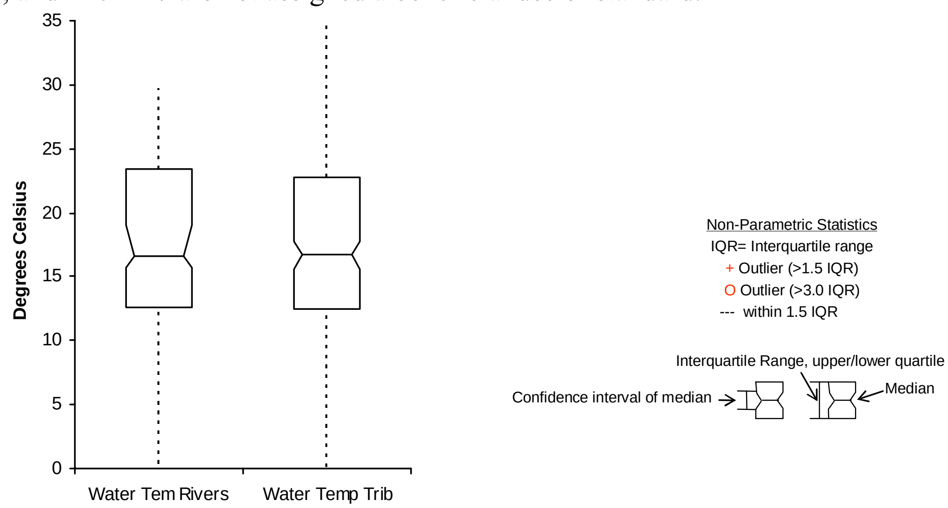


Figure 26. Box and Whisker Plot of Water Temperature for River and Tributary Sites

Conductivity

Conductivity ranged from a minimum of 81 µmhos/cm (T26-West Pipestone Creek) to a maximum of 2,082 µmhos/cm (T23-Skunk Creek) for all tributary sites T01 through T33 (See Figure 27). The lowest mean was 435 µmhos/cm (T27) and the highest mean was 1,356 µmhos/cm (T10). The lowest median of 470 µmhos/cm was at site T32 and the highest median of 1,507 µmhos/cm was at site T10.

Conductivity ranged from a minimum of 146 µmhos/cm (R09-BSR at Hwy 38A) to a maximum 1,264 µmhos/cm (R11-BSR at North Cliff Avenue) for all river sites R01 through R13 (See Figure 27). The lowest mean was 699 µmhos/cm (R09) and the highest mean was 914 µmhos/cm (R03). The lowest median of 691 µmhos/cm was at site R05 and the highest median of 942 µmhos/cm was at site R03.

There is no standard or assigned beneficial use for this parameter.

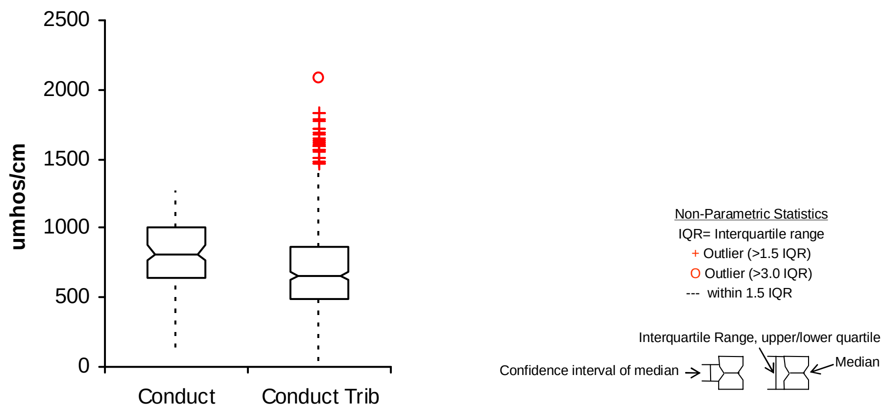


Figure 27. Box and Whisker Plot of Conductivity for Rivers and Tributary Sites

Specific Conductivity

Specific conductivity ranged from a minimum of 124 µmhos/cm (T08-Medry Creek) to a maximum of 1,965 µmhos/cm (T10-Lake Campbell Outlet) for all tributary sites T01 through T33 (See Figure 28). The lowest mean was 542 µmhos/cm (T27) and the highest mean was 1,498 µmhos/cm (T17). The lowest median of 559 µmhos/cm was at site T07, and the highest median of 1,570 µmhos/cm was at T10.

Specific conductivity ranged from a minimum of 318 µmhos/cm (R13-BSR near Gitchie Manitou) to a maximum of 1,512 µmhos/cm (R11-BSR at North Cliff Avenue) for all river sites R01 through R13 (See Figure 28). The lowest mean was 792 µmhos/cm at R06 and the highest mean was 979 µmhos/cm at R12. The lowest median of 792 µmhos/cm at R06 and the highest median of 1,080 µmhos/cm were at site R10.

A single grab sample daily maximum of the most restrictive standard of 4,375 µmhos/cm was used to determine the percent violations and assess for the beneficial use support of (9) Fish and Wildlife Propagation, Recreation, and Stock Watering and (10) Irrigation for all of the tributary and river sites. Using this criterion, all tributary sites T01-T33 and all river sites R01-R13 are fully supporting of this parameter.

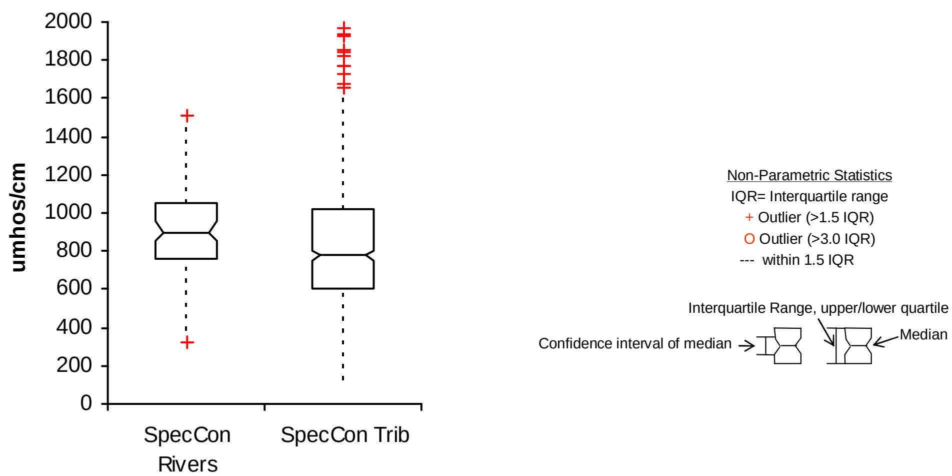


Figure 28. Box and Whisker Plot of Specific Conductivity for Rivers and Tributary Sites

Salinity

Salinity ranged from a non detect (T15-North Buffalo Creek and T26-West Pipestone Creek) to a maximum of 1.0 ppt (several sites) for all tributary sites T01 through T33 (See Figure 29). The lowest mean was 0.3 ppt at several sites and the highest mean was 0.8 ppt (T17). The lowest median of 0.3 ppt was at several sites and the highest median of 0.8 ppt was at site T17.

Salinity ranged from a minimum of 0.1 ppt (several sites) to a maximum 0.8 ppt (R11-BSR at North Cliff Avenue and R12-BSR at Brandon) for all river sites R01 through R13 (See Figure 29). The lowest mean was 0.4 ppt for most sites and the highest mean was 0.5 ppt (R10 and R12). The lowest median of 0.4 ppt was at several sites and the highest median of 0.5 ppt was at several sites.

There is no standard or assigned beneficial use for this parameter.

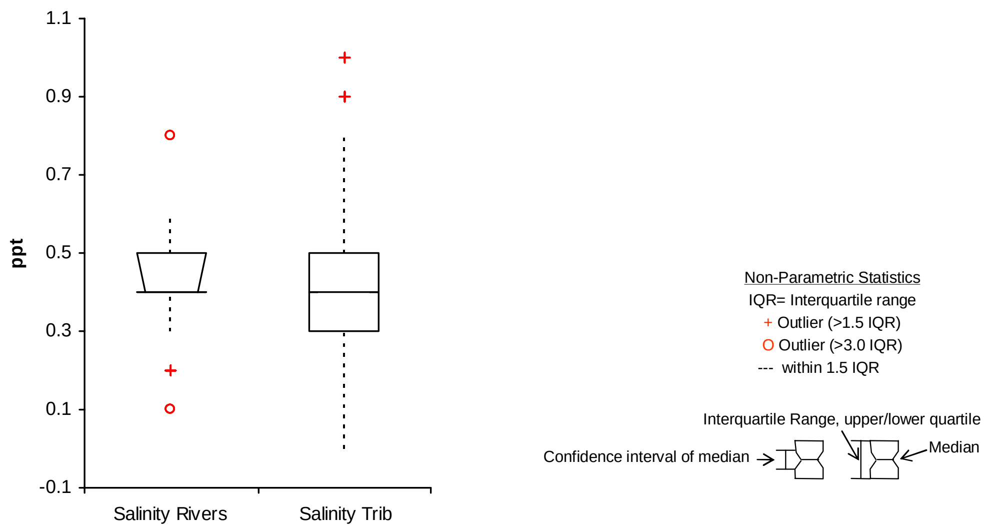


Figure 29. Box and Whisker Plot of Salinity for River and Tributary Sites

Turbidity - NTU

Turbidity ranged from a minimum of 0.1 NTU (T14-Bachelor Creek) to a maximum of 3,066 NTU (T33-Beaver Creek) for all tributary sites T01 through T33 (See Figure 30). The lowest mean was 8.7 NTU at Site T17 and the highest mean was 290.3 NTU (T32). The lowest median of 4.4 NTU was at Site T14 and the highest median of 45 NTU was at Site T30.

Turbidity ranged from a minimum of 4.3 NTU (R01-BSR near Brookings) to a maximum 2,043 NTU (R13-BSR near Gitchie Manitou) for all river sites R01 through R13 (See Figure 30). The lowest mean was 37.6 NTU for R01 and the highest mean was 210.1 NTU (R13). The lowest median of 27.1 was at Site R01 and the highest median of 66.4 at Site R03.

There is no standard or assigned beneficial use for this parameter.

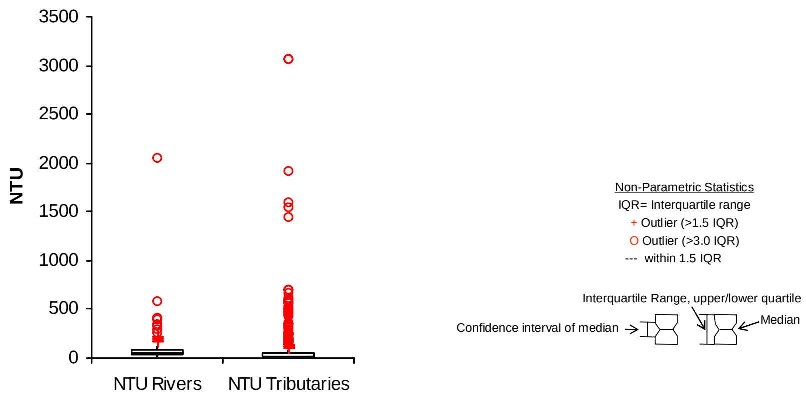


Figure 30. Box and Whisker Plot of Turbidity (NTU) for River and Tributary Sites

Load Duration Curves

The load duration curve methodology used by the Nevada Division of Environmental Protection aided in the development of EDWDD load duration curves for TSS and fecal coliform. Load duration curves serve as a tool that provides a visual representation of the loadings that are allowable based on daily flows, at a particular standard, over a period of time, such as 20 years. The curve (Figure 31) represents an exceedence threshold for a water quality standard at a particular flow. Points, or water quality samples, plotted above this line represents an exceedence of water quality standards.

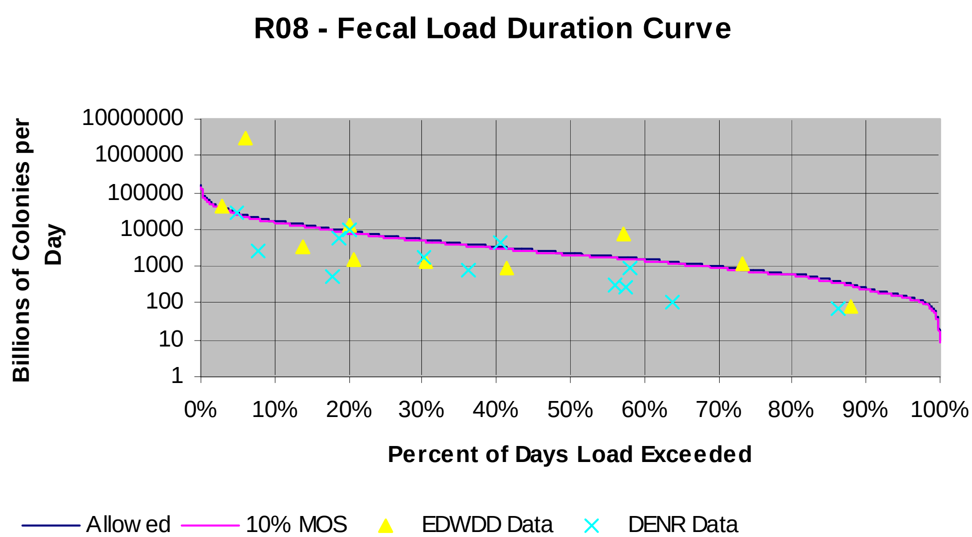


Figure 31. Example of a Load Duration Curve

The exceedence is represented as a percentage of days (ranging from 0 to 100). Flow conditions can be predicted based on where each sample is plotted. For instance, an exceedence in the 0-10 percent region indicates extremely high flows. At flows such as these, causes of the exceedence would be impossible to reasonably manage. Exceedences found in the 90-100 percent range may indicate a point-source problem. In this range, base flows are at low or drought conditions.

Fecal Coliform Bacteria Load Duration Curves

The fecal coliform bacteria load duration curves are located in Appendix EE. Each graph corresponds to the fecal exceedence tables located in Appendix FF, and serves as a visual aid in determining if there are nonpoint source, point source, and/or unmanageable problems. The upper line on the graphs of R01 through R07 represents the 2000 cfu/100mL water quality standard for beneficial use (8) Limited Contact Recreation. The 400 cfu/100mL standard was applied to all river sites, represented by the lower line on graphs R01 through R07, for comparison analysis and also due to the fact that the lower mainstem sites, R08 through R13 have a standard of 400 cfu/100mL to meet beneficial use (7) Immersion Recreation. Load duration curves were designed for all the mainstem BSR sites.

Comparisons can be made between the percent of violations and the actual load reductions to predict what may be causing the violations and to what extend the violations should be reduced to meet beneficial uses. Evaluation of these curves aid in differentiating water quality conditions among the sites. An examination of the following curves for each subwateshed can be found in the Analysis and Summary Section.

TSS Load Duration Curves

The TSS load duration curves are located in Appendix GG. Each graph corresponds to the TSS exceedence tables located in Appendix HH, and serves as a visual aid in determining if there are nonpoint source, point source, and/or unmanageable problems. Comparisons can be made between the percent of violations and the actual load reductions to predict what may be causing the violations and to what extent the violations should be reduced to meet beneficial uses. Evaluation of these curves aid in differentiating water quality conditions among the sites.

BIOLOGICAL MONITORING

Fish Sampling

Data from the fish surveys at each site were compiled into a fisheries collection report, which was submitted to the SD GFP for each year of sampling (See Appendix II). Life history designations for fishes found during the CBSRWAP is located in Appendix JJ. Fish were surveyed in the tributary sites, with the exception of sites T12 and T24 which are intermittent streams and became dry before sampling could be completed. The Big Sioux River sites were not surveyed for fish. Results of the candidate fish metrics can be found in Appendix KK.

Rare, Threatened, and Endangered Species

Rare, threatened and endangered species of fishes were documented during the assessment of the Central BSR watershed. Fishes that were found included the Topeka Shiner, Trout-Perch, and Blackside Darter (See Table 29). The Topeka Shiner is listed as federally endangered by the US Fish and Wildlife service. The Trout-Perch is a state threatened species, and the Blackside Darter is state listed for its rarity. State and federal agencies should be notified before implementing any future projects in the Central BSR watershed. See Appendix II for numbers and locations where they were found.

Table 29. Rare, Threatened, and Endangered Fish Species Found in the CBSRW

Common Name	Scientific Name	Federal Status	State Status	Global Rank	State Rank
Topeka Shiner	*Notropis topeka*	LE		G2	S2
Trout Perch	*Percopsis omiscomaycus*		ST	G5	S2
Blackside Darter	*Percina maculata*			G5	S2

Note: LE = Listed Endangered
ST = State Threatened
G2/S2 = Imperiled because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor (s) making it very vulnerable to extinction throughout its range
G5 = Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery

Fish index scores from each monitoring site were compiled and graphed. Figure 32 visually shows the category in which each site fell. Categories were derived by first ordering the final index scores for each monitoring site, from highest to lowest and calculating the percent rank of n=31. The three categories designated for fish are 24-51 (poor), 52-72 (fair), and 73-90 (good). Anything scoring above 94 would be considered occurring within pristine conditions. Most sites fell within the fair category. Sites T01, T10, T15, T16, T17, T25, and T32 fell with in the poor category. Sites that rated ‘good’ included T07, T08, T09, T23, T28, T29, T30, and T33.

It should be noted that a reference network involving macroinvertebrates, fish, or habitat data was not used in the development of this classification system. The classification of sites into one of the three impairment categories is based solely on the biological data collected during the Central and North Central Watershed Assessment Projects. The sites were compared to themselves and not to a known biological benchmark.

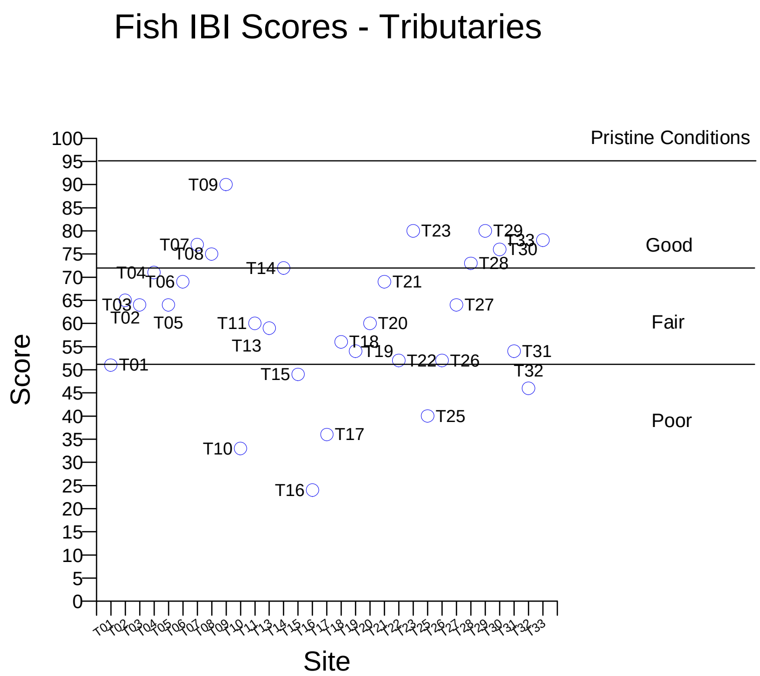


Figure 32. Scatterplot of Fish IBI Scores

Macroinvertebrate Sampling

Macroinvertebrate sampling occurred within all the tributary and river sites, with the exception of T01, T02, T03, and T16, all of which are intermittent streams and became dry before October when the macroinvertebrates were collected. Laboratory work and compilation of the results for each metric were outsourced to the researchers of EcoAnalyst, Inc., and Natural Resource Solutions. These results can be found in Appendix LL. Frequency graphs were constructed based on the Hilsenhoff Biotic Index (HBI) score each site received (See Figures 33 and 34). Separate graphs were made, one for the tributary sites and another for the river sites. The most frequent HBI score the tributary sites received was 5.0-5.5. The most frequent HBI score the river sites received was 6.0-6.5. The majority of the tributary sites had HBI scores that fell below 5.9, whereas the majority of the river sites fell above 5.9.

The HBI is based on an average relative sensitivity to stream quality conditions. The HBI score ranges from 0 to 10, with 0 being the least tolerant to organic pollution and 10 being the most tolerant to organic pollution (Hilsenhoff 1987).

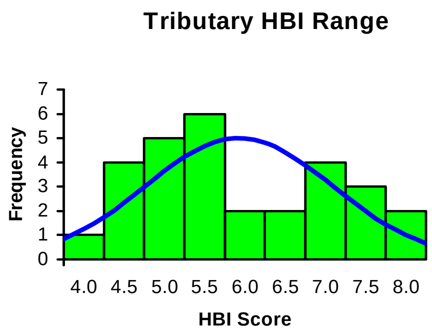
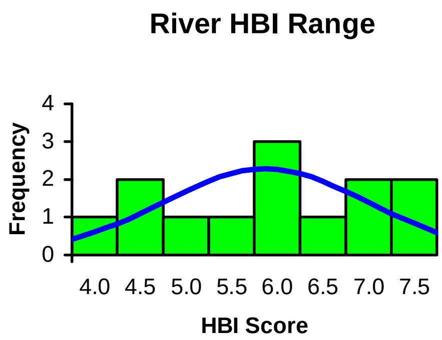


Figure 33. Frequency Curve of Tributary Site HBI Scores

n	29
Mean	6.176
95% CI	5.737to 6.615
Variance	1.3321
SD	1.1542
SE	0.2143
CV	19%



n	13
Mean	6.13
95% CI	5.43to 6.82
Variance	1.311
SD	1.145
SE	0.318
CV	19%

Figure 34. Frequency Curve of River Site HBI Scores

Macroinvertebrate index scores from each monitoring site, n=42, were compiled and graphed. Figure 35 visually shows the category in which each site fell. The categories are 18-61 (poor), 62-72 (fair), 73-86 (good). Anything scoring above 94 would be considered occurring within pristine conditions. The majority of the sites fell within the fair category. Sites R03-R05, T04, T07, T13, T17, T18, T24, and T26, fell within the poor category. Sites that rated ‘good’ include R08, R10, R12, R13, T12, T21, T23, T27, T28, T30, T32, and T33.

It should be noted that a reference network involving macroinvertebrates, fish, or habitat data was not used in the development of this classification system. The classification of sites into one of the three impairment categories is based solely on the biological data collected during the Central and North Central Watershed Assessment Projects. The sites were compared to themselves and not to a known biological benchmark.

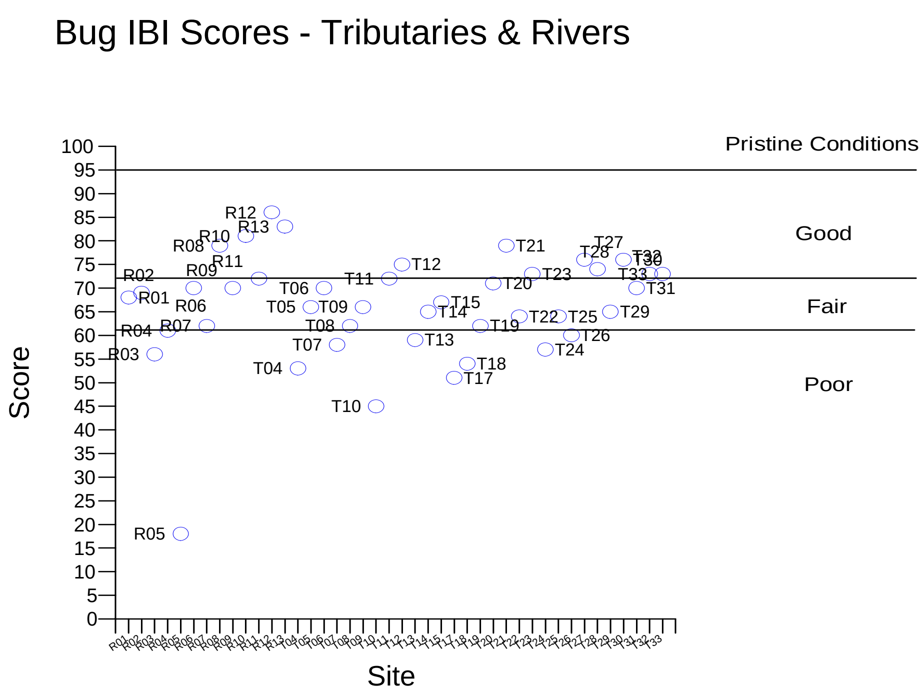


Figure 35. Scatterplot of Macroinvertbrate IBI Scores

PHYSICAL HABITAT MONITORING

Habitat Assessment

Physical habitat sampling occurred within all the tributary sites, with the exception of sites T12 and T24 which are intermittent streams and became dry before sampling could be completed. The Big Sioux river sites were not surveyed for fish or physical habitat. Physical habitat index scores from each monitoring site, n=31, were compiled and graphed. Figure 36 visually shows the category in which each site fell. The categories are 31-46 (poor), 50-64 (fair), 65-80 (good). Anything scoring above 94 was considered occurring within pristine conditions. The majority of the sites fell within the fair category. Sites T08, T17-T19, T22, T26, T27, T32, and T33 fell within the poor category. Sites that rated 'good' included T01, T03, T04, T14, T20, T23, T25, and T29.

It should be noted that a reference network involving macroinvertebrates, fish, or habitat data was not used in the development of this classification system. The classification of sites into one of the three impairment categories is based solely on the biological data collected during the Central and North Central Watershed Assessment Projects. The sites were compared to themselves and not to a known biological benchmark.

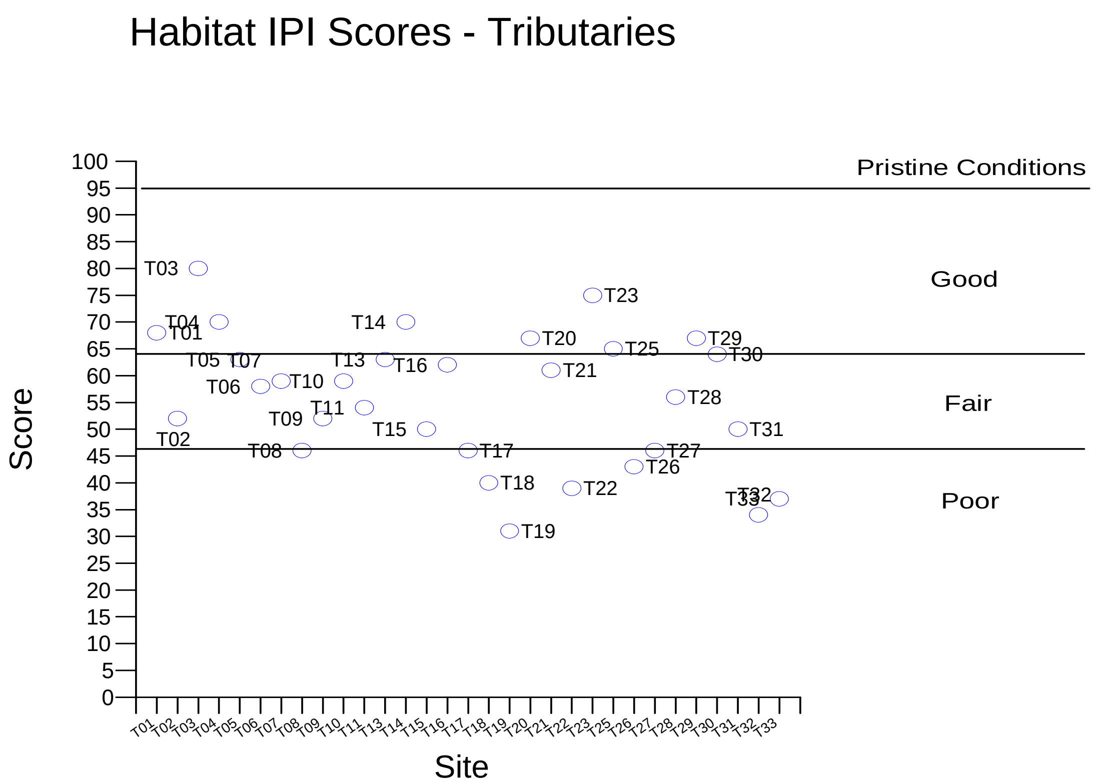


Figure 36. Scatterplot of Physical Habitat IPI Scores

ASSESSMENT OF SOURCES

Point Sources

Wastewater Treatment Facilities (NPDES)

The following table (Table 30) represents the percent contribution of TSS from each wastewater treatment facility in the study area during the study period. The 'Ave L/day' column is figured by the following:

(average millions of gallons a day) × (conversion from millions gallons a day to cubic feet per second) × (seconds in a day) × (conversion from cubic feet to liters)

The 'Total mg' column is figured multiplying the following columns:

(Ave L/day) × (Ave mg/L) × (Days Discharge)

The '% of Total' column is figured by the following columns:

(Total kg ÷ Total TSS (kg) from FLUX) ×100

Table 30. NPDES Percent Contributions of TSS

Big Sioux River Watershed	NPID	Total Retenion	Ave. MGD	Ave L/day	Ave mg/L	Days Discharge	Total mg	Total kg	Total TSS (kg) from Flux	% of Total	Remarks
Brookings to I-29											
Brookings, City of	SD0023388	No	2.812	10644569.7	4.85	240	12390279124	12390.279	2.52E+07	0.04925	
Medary Creek Watershed											
Aurora, City of	SD0021661	No	NA	----	NA	----	----	----	----	----	No Discharges
Six Mile Creek Watershed											
White, City of	SD0021636	No	2.22	8403607.65	16.4	60	8269149931	8269.150	4.44E+05	1.86094	
South Dakota State University	SD0026832	No	NA	----	NA	----	----	----	----	----	No Discharges
I-29 to Near Dell Rapids											
Flandreau , City of	SD0021831	No	0.175	662446.549	34.5	30	685632178.5	685.632	2.50E+07	0.00274	
Egan , Town of	SD0022462	No	0.358	1355176.37	140	1	189724691.7	189.725	2.84E+07	0.00067	One day average load
Trent, Town of	SD0020265	Yes	NA	----	97	----	----	----	----	----	
Spring Creek Watershed											
Elkton , City of	SD0020788	No	0.6509	2463846.91	12	30	886984889.1	886.985	2.14E+05	0.41459	
Bachelor Creek Watershed											
Wentworth , Town of	SD0026204	Yes	NA	----	NA	----	----	----	----	----	No Discharges
Near Dell Rapids to Below Baltic											
Dell Rapids, City of	SD0022101	No	1.44	5450988.75	15.25	30	2493827352	2493.827	6.48E+07	0.00385	
Baltic, Town of	SD0022284	No	NA	----	NA	----	----	----	----	----	No Discharges
LG Everist, INC	SD0000051	No	1.7	6435195.05	9.84	240	15197356630	15197.357	6.48E+07	0.02346	

Table 30 continued

Big Sioux River Watershed	NPID	Total Retenion	Ave. MGD	Ave L/day	Ave mg/L	Days Discharge	Total mg	Total kg	Total TSS (kg) from Flux	% of Total	Remarks
Below Baltic to Skunk Creek											
Concrete Materials, INC	SD0000302	Yes	NA	----	NA	----	----	----	----	----	No Discharges
SD State Penitentiary - West	SD0020427	Yes	NA	----	NA	----	----	----	----	----	No Discharges
North Buffalo Creek Watershed											
Dakota Ethanol				Didn't exist during time of study, but has been included in the TMDLs							
Colton Creek Watershed											
Colton, City of	SD0022322	No	0.564	2134970.6	21.3	30	1364246209	1364.246	4.66E+06	0.02927	
Tri-Valley School District	SD0027278	Yes	NA	----	NA	----	----	----	----	----	No Discharges
Willow Creek Watershed											
Crooks Water & Sewer	SD0020761	No	1.96	7419401.4	42.37	90	28292403174	28292.403	5.71E+06	0.53483	
Skunk Creek Watershed											
Chester Sanitary District	SD0020338	No	NA	----	29	----	----	----	----	----	TSS discharge one day only
Williams Pipeline Co #213	SD0026981	No	N A	----	NA	----	----	----	----	----	No Discharges
Wall Lake Sanitary District	SD0026778	No	NA	----	NA	----	----	----	----	----	No Discharges
Hartford, City of	SD0021750	No	0.257	972850.08	21.2	240	4949861183	4949.861	4.18E+07	0.01170	
Humboldt, City of	SD0024015	Yes	NA	----	NA	----	----	----	----	----	No Discharges
Sioux Falls (MS4)				---To Be Determined---							
Skunk Creek to Diversion Return											
John Morrell & Company	SD0000078	No	2.12	8025066.8	5.07	240	9764901243	9764.901	1.19E+08	0.00822	
Sioux Falls (MS4)				---To Be Determined---							
Diversion Return to SF WWTF											
Sioux Falls (MS4)				---To Be Determined---							
SF WWTF to Above Brandon											
Sioux Falls, City of (WWTF)	SD0022128	No	15.89	60150147	2	240	28872070403	28872.070	1.34E+08	0.02154	
Northern States Power-Pathfind	SD0000264	No	NA	----	NA	----	----	----	----	----	Cooling Water Only
Split Rock Creek Subwatershed											
West Pipestone Watershed											
USGS - EROS Data Center	SD0000299	No	0.3315	1254863	8.9	60	670096860.5	670.097	2.42E+07	0.00277	
Split Rock Creek Watershed											
Garretson, City of	SD0022560	Yes	NA	----	NA	----	----	----	----	----	No Discharges
Corson Village Sanitary District	SD0022217	Yes	NA	----	NA	----	----	----	----	----	No Discharges
Beaver Creek Watershed											
Valley Springs, City of	SD0020923	No	----	21600	10.3	1	222480	0.222	4.25E+07	0.00000	TSS discharge one day only
*Brandon, City of	SD0022535	No	0.5946	2250804.1	23.13	150	7809164839	7809.165	4.54E+08	0.00172	

*The City of Brandon discharges into the Big Sioux River but is not draining into any TMDL segments

The following table (Table 31) represents the percent contribution of fecal coliform bacteria from each wastewater treatment facility in the study area during the study period. The 'Ave ft^3/day' column is figured by the following:

(average millions of gallons a day) × (conversion from millions of gallons a day to cubic feet per second) ×(seconds in a day)

The 'CFU's' column is figured by multiplying the following columns:

(Ave ft^3/day) × (Ave Conc) × (Days Discharge)

The '% of Total' column is figured by the following columns:

(CFUs ÷ Total CFU from FLUX) ×100

Table 31. NPDES Percent Contributions of Fecal Coliform Bacteria

Big Sioux River Watershed	NPID	Total Retenion	Ave. MGD	Ave ft3/day	Ave Conc.	Days Discharge	CFU's	Total CFU from FLUX	% of Total	Remarks
Brookings to I-29										
Brookings, City of	SD0023388	No	2.812	375910.05	7	240	631528883	4.04E+14	0.00016	
Medary Creek Watershed										
Aurora, City of	SD0021661	No	NA	----	NA	----	----	----	----	No Discharges
Six Mile Creek Watershed										
White, City of	SD0021636	No	2.22	296771.09	10	60	178062655	3.15E+14	0.00006	
South Dakota State University	SD0026832	No	NA	----	NA	----	----	----	----	No Discharges
I-29 to Near Dell Rapids										
Flandreau, City of	SD0021831	No	0.175	23394.118	9	30	6316411.75	1.55E+15	0.0000004	
Egan, Town of	SD0022462	No	0.358	47857.681	21000	1	1005011292	6.31E+15	0.00002	
Trent, Town of	SD0020265	Yes	NA	----	NA	----	----	----	----	
Spring Creek Watershed										
Elkton, City of	SD0020788	No	0.65088	87010.076	80	30	208824182	1.30E+14	0.00016	
Bachelor Creek Watershed										
Wentworth, Town of	SD0026204	Yes	NA	----	NA	----	----	----	----	No Discharges
Near Dell Rapids to Below Baltic										
Dell Rapids, City of	SD0022101	No	1.44	192500.17	79	30	456225397	1.05E+15	0.00004	
Baltic, Town of	SD0022284	No	NA	----	NA	----	----	----	----	No Discharges
LG Everist, INC	SD0000051	No	1.7	227257.14	NA	240	----	1.05E+15	----	No fecal data
Below Baltic to Skunk Creek										
Concrete Materials, INC	SD0000302	Yes	NA	----	NA	----	----	----	----	No Discharges
SD State Penitentiary - West	SD0020427	Yes	NA	----	NA	----	----	----	----	No Discharges
North Buffalo Creek Watershed										
Dakota Ethanol				Didn't exist during time of study, but has been included in the TMDLs						
Colton Creek Watershed										
Colton, City of	SD0022322	No	0.564	75395.899	No Data	30	----	----	----	No fecal limit
Tri-Valley School District	SD0027278	Yes	NA	----	NA	----	----	----	----	No Discharges
Willow Creek Watershed										
Crooks Water & Sewer	SD0020761	No	1.96	262014.12	No Data	90	----	----	----	No fecal limit
Skunk Creek Watershed										
Chester Sanitary District	SD0020338	No	NA	----	NA	----	----	----	----	No Discharges
Williams Pipeline Co #213	SD0026981	No	N A	----	NA	----	----	----	----	No Discharges
Wall Lake Sanitary District	SD0026778	No	NA	----	NA	----	----	----	----	No Discharges
Hartford, City of	SD0021750	No	0.257	34355.933	185	240	1525403412	1.18E+16	0.00001	high daily max #s
Humboldt, City of	SD0024015	Yes	NA	----	NA	----	----	----	----	No Discharges
Sioux Falls (MS4)				------------------------------------To Be Determined--------------------------------						
Skunk Creek to Diversion Return										
John Morrell & Company	SD0000078	No	2.12	283403.02	12	240	816200711	2.12E+15	0.00004	
Sioux Falls (MS4)				------------------------------------To Be Determined--------------------------------						
Diversion Return to SF WWTF										
Sioux Falls (MS4)				------------------------------------To Be Determined--------------------------------						
SF WWTF to Above Brandon										
Sioux Falls, City of (WWTF)	SD0022128	No	15.89	2124185.9	37	240	1.8863E+10	2.37E+15	0.00080	
Northern States Power-Pathfind	SD0000264	No	NA	----	NA	----	----	----	----	Cooling Water Only
Split Rock Creek Area										
West Pipestone Watershed										
USGS - EROS Data Center	SD0000299	No	0.3315	44315.143	No Data	60	----	----	----	No fecal limit
Split Rock Creek Watershed										
Garretson, City of	SD0022560	Yes	NA	----	NA	----	----	----	----	No Discharges
Corson Village Sanitary Dist	SD0022217	Yes	NA	----	NA	----	----	----	----	No Discharges
Beaver Creek Watershed										
Valley Springs, City of	SD0020923	No	NA	----	NA	----	----	----	----	No Discharges
*Brandon, City of	SD0022535	No	0.5946	79486.528	56	150	667686832	1.05E+16	0.0000064	

*The City of Brandon discharges into the Big Sioux River but is not draining into any TMDL segments

Note: all facility data is based on 30 day geomean

Municipal Separate Stormwater Sewer System (MS4)

As described in the Methods Section, the City of Sioux Falls MS4 permit is non-specific in its allowable urban runoff contribution. However, a discharge characterization study was performed which estimated TSS to be 10,123,188 pounds per year. There were no estimates for fecal coliform. For this reason, when the Sioux Falls MS4 permit is reissued, the allowable TSS WLA and BMPs necessary to achieve the reductions from this source need to be incorporated into the permit conditions. It is assumed the MS4 is currently operating well within its allowable limits for fecal coliform bacteria and TSS. Until further analysis is completed specific contributions from this source can not be estimated.

Non Point Sources

Urban Stormwater Runoff

Based on the two methods described in the methods section, under Urban Stormwater Runoff, both resulted in a four percent relative contribution of TSS from the vicinity of the City of Sioux Falls. This percentage represents the well-developed residential, commercial, and industrial areas, however this percentage could increase with increased construction erosion activities if proper stormwater management is not implemented. For the purpose of this study, the City of Sioux Falls will be considered a point source of urban stormwater runoff due to the size of the city and because it is permitted as a Municipal Separate Stormwater Sewer System. Methods used to derive contributions can be found in the Methods Section under ASSESSMENT OF SOURCES – Point Sources.

Agricultural Runoff

Agricultural runoff was taken into account when the Sediment Delivery Model calculated land use scenarios for TSS reductions. Also, agricultural runoff was taken into account when AGNPS was used to perform ratings on the feedlots in the study area. This information was then incorporated in the process of prioritizing watershed areas for fecal reduction.

Background Wildlife Contribution

The average contribution from deer is 1.7 percent, watershed wide (See Table 32). The 1.7 percent will be used as an average when assessing each monitoring site. This number assumes a 100 percent contribution of fecal coliform bacteria is delivered into the receiving waters. Therefore, due to its unrealistic 100 percent delivery only for deer, it will represent all wildlife contributions in this watershed for this project.

Table 32. Wildlife Contribution of Fecal Coliform Bacteria

Wildlife Background CFU's

Site	Deer/Ac.	Acres	Deer	Days	CFU's/deer/day	CFU's	Total CFU's	% deer
T19	0.0056	40549	227	240	5.00E+08	2.72E+13	1.96E+15	1.4
T20	0.0056	43236	242	240	5.00E+08	2.91E+13	4.91E+15	0.6
T22	0.0056	30682	172	240	5.00E+08	2.06E+13	7.82E+14	2.6
T25	0.0056	14624	82	240	5.00E+08	9.83E+12	5.74E+14	1.7
T26	0.0056	33011	185	210	5.00E+08	1.94E+13	8.28E+14	2.3
							Average	1.7

Failing Septic Systems Contribution

The calculated contribution from failing septic systems is 18.2 percent, watershed wide (See Table 33). The 18.2 percent will be used as an average when assessing each monitoring site. However, this percentage is very high because it assumes that all the rural septic systems are failing and reaching the receiving waters. The number of onsite septic systems in the study area is unknown. However, according to the EPA (2002a) failure rates of onsite septic systems range from 10 to 20 percent, with a majority of these failures occurring with systems 30 or more years old. Until there is better factual data on the conditions of the rural septic systems in this study area, the 18.2 percent average will be used, however unlikely it seems. Although, assumptions that only a small percentage of this number (18.2 percent) is actually failing septics may be warranted in circumstances where livestock situations are clearly the predominant factor in the fecal coliform bacteria loadings.

Table 33. Failing Septic System Contribution of Fecal Coliform Bacteria

					Failing Septic Contribution CFU's			
Site	People per household	#households	People	Days	CFU's/person/day	CFU's	Total CFU's	% people
T19	2.5	82	205	240	2.00E+09	9.84E+13	1.96E+15	5.0
T20	2.5	82	205	240	2.00E+09	9.84E+13	4.91E+15	2.0
T22	2.5	241	603	240	2.00E+09	2.89E+14	7.82E+14	37.0
T25	2.5	168	420	240	2.00E+09	2.02E+14	5.74E+14	35.1
T26	2.5	92	230	210	2.00E+09	9.66E+13	8.28E+14	11.7
							Average	18.2

Modeling

Correlation of the FLUX model and the Sediment Delivery Model (SDM)

A comparison of the FLUX model output and the sediment delivery model (SDM) output showed a positive relationship. High flow TSS yields from the FLUX model were compared to the 2, 5, 10, and 20 year rainfall event TSS yields for the BSR sites and also for the tributary sites. Correlation coefficients for the BSR sites ranged from 0.315 to 0.409, with a $p < 0.001$, $n = 11$, and $df = 10$ (See Figure 37). Correlation coefficients for the tributary sites ranged from 0.678 to 0.711 with a $p < 0.001$, $n = 11$, and $df = 10$. Scatterplots with confidence intervals are also shown. (See Figure 38). The significant positive correlation between the FLUX results and the SDM results show that net loads (FLUX) increased as the amount of rainfall increased (SDM). The obvious BSR outliers of R08, R12, and R13 may be in direct relation to those sites being immediately downstream of the towns of Dell Rapids or Sioux Falls.

Pearson correlation matrix

	FLUXDIFF	TONSACRE_2	TONSACRE_5	TONSACRE_10	TONSACRE_20
FLUXDIFF	1.000				
TONSACRE_2	0.409	1.000			
TONSACRE_5	0.365	0.989	1.000		
TONSACRE_10	0.335	0.974	0.997	1.000	
TONSACRE_20	0.315	0.955	0.988	0.997	1.000

Bartlett Chi-square statistic: 198.446 df=10 Prob= 0.000

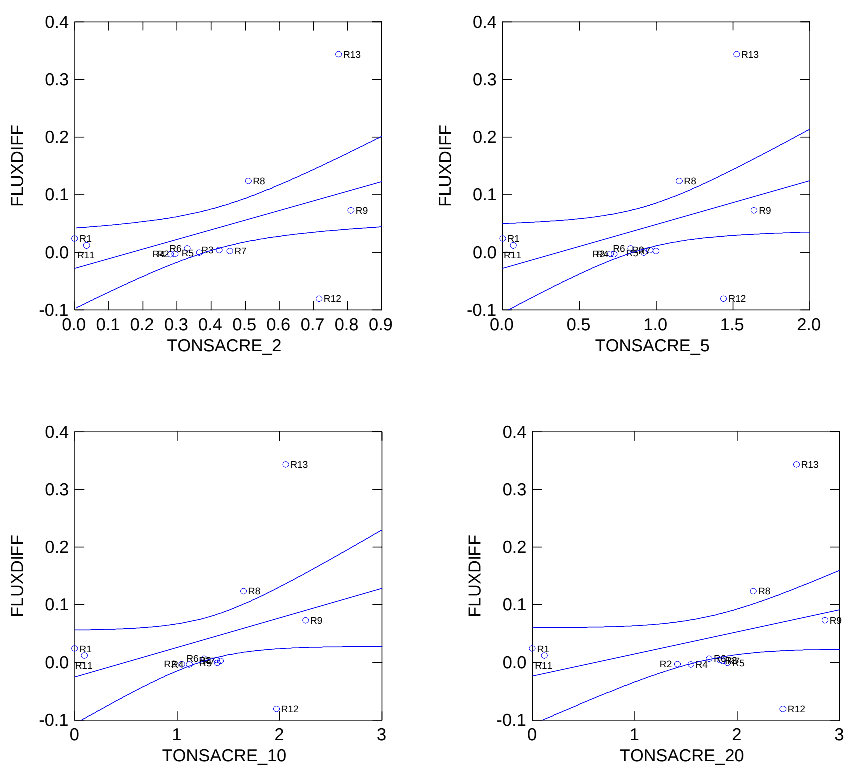


Figure 37. FLUX vs SDM Pearson Correlation Matrix for River Sites

Pearson correlation matrix

	FLUXDIFF	TONSACRE_2	TONSACRE_5	TONSACRE_10	TONSACRE_20
FLUXDIFF	1.000				
TONSACRE_2	0.711	1.000			
TONSACRE_5	0.705	0.987	1.000		
TONSACRE_10	0.695	0.966	0.995	1.000	
TONSACRE_20	0.678	0.940	0.982	0.996	1.000

Bartlett Chi-square statistic: 594.562 df=10 Prob= 0.000

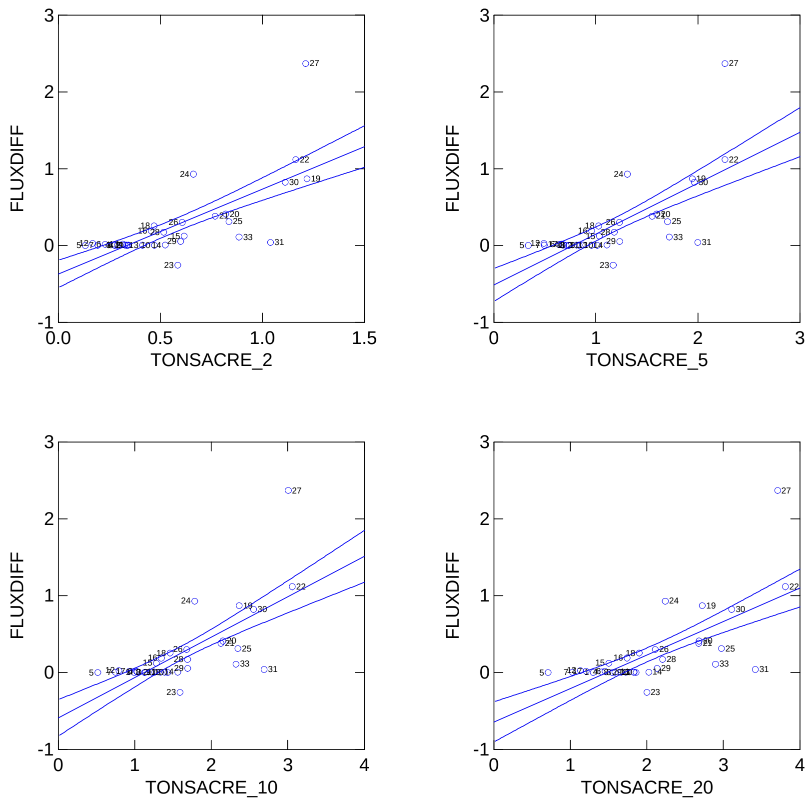


Figure 38. FLUX vs SDM Pearson Correlation Matrix for Tributary Sites

FLUX Modeling

The FLUX Model (Army Corps of Engineers Loading Model) was used to estimate the nutrient loadings for each site. These loads and their standard errors (CV) were calculated and are presented in Appendix T. Sample data collected during this project, an earlier project, as well as by the United States Geological Survey (USGS) were utilized in the calculation of the loads and concentrations. Results from the FLUX model were also used to in finding percent reductions needed for TSS (See Appendix MM).

Sediment Delivery Model (SDM)

As Figure 39 indicates, the CBSRW was divided into land management units (LMUs). Each LMU is a sub-watershed of the CBSRW. Once these LMUs were formed, the SDM could run 2, 4, 10, 20 year, 24 hour rainfall events and predict sediment loads.

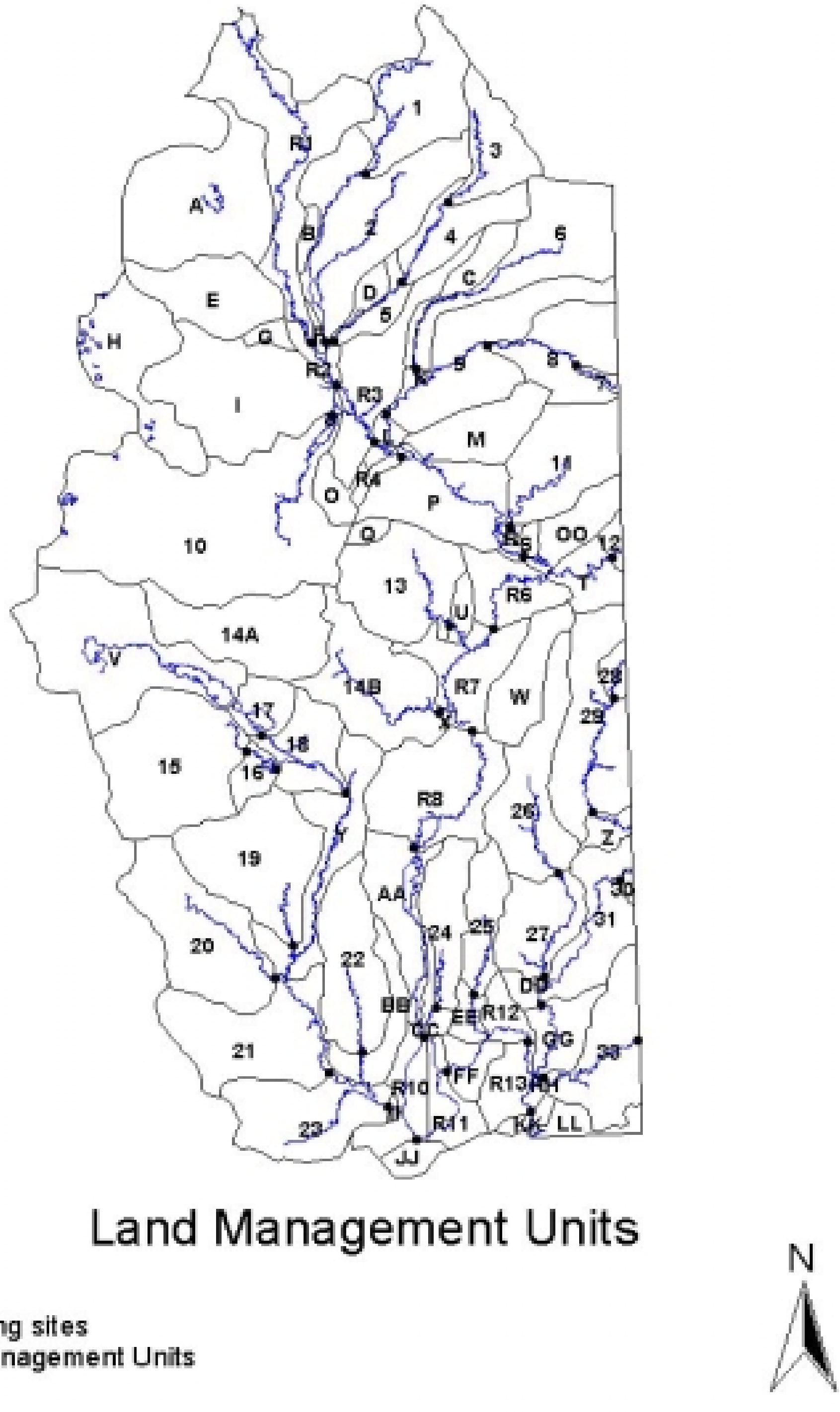


Figure 39. Land Management Units of the BSRW Study Area

The SDM also produced a land cover map (See Figure 40). Land cover is broken down by subwatershed in the Analysis and Summary Section. Land cover is further reduced by site in Figure 41 and Figure 42. Appendix NN also shows detailed landuse information by site.

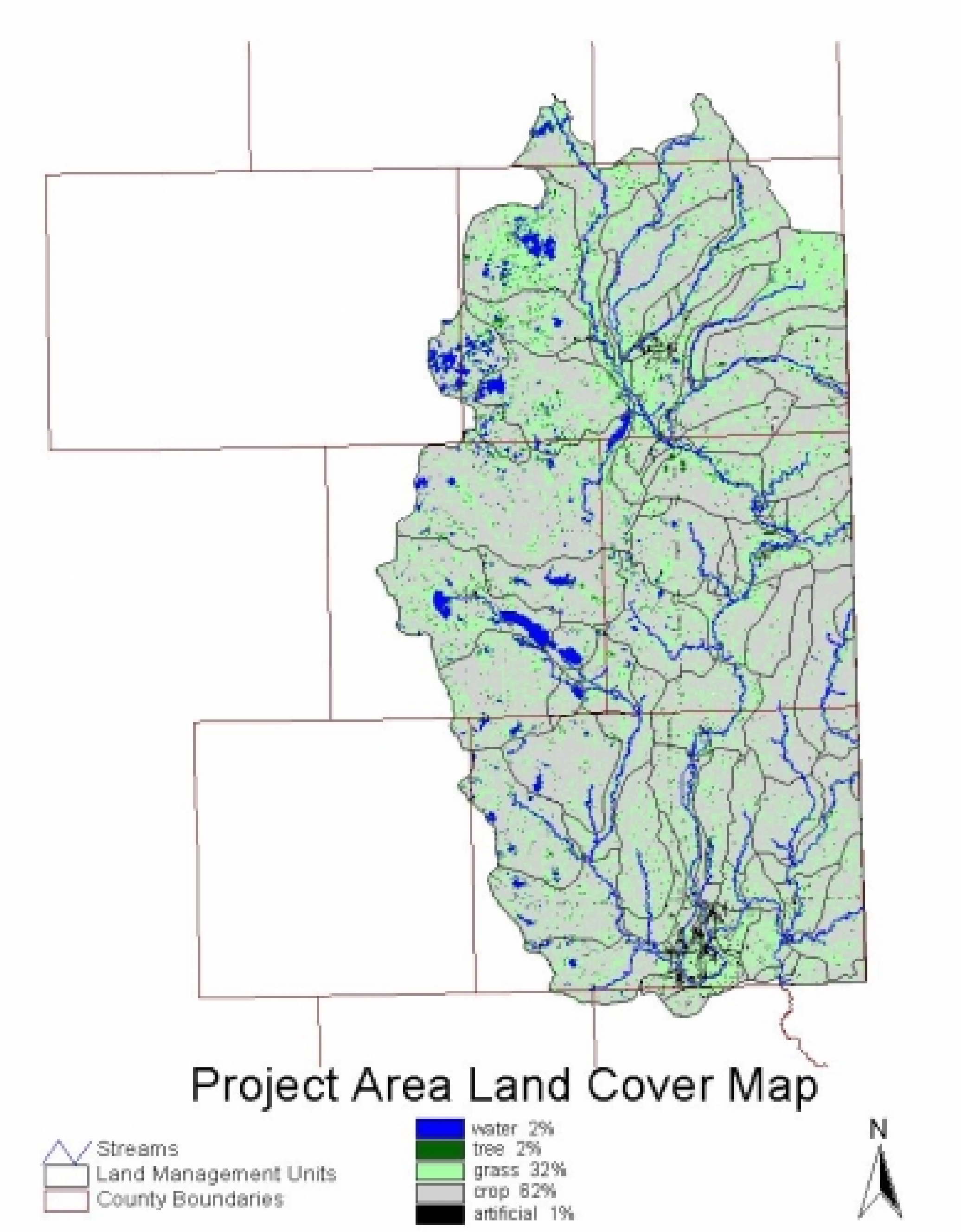


Figure 40. Project Area Land Cover Map

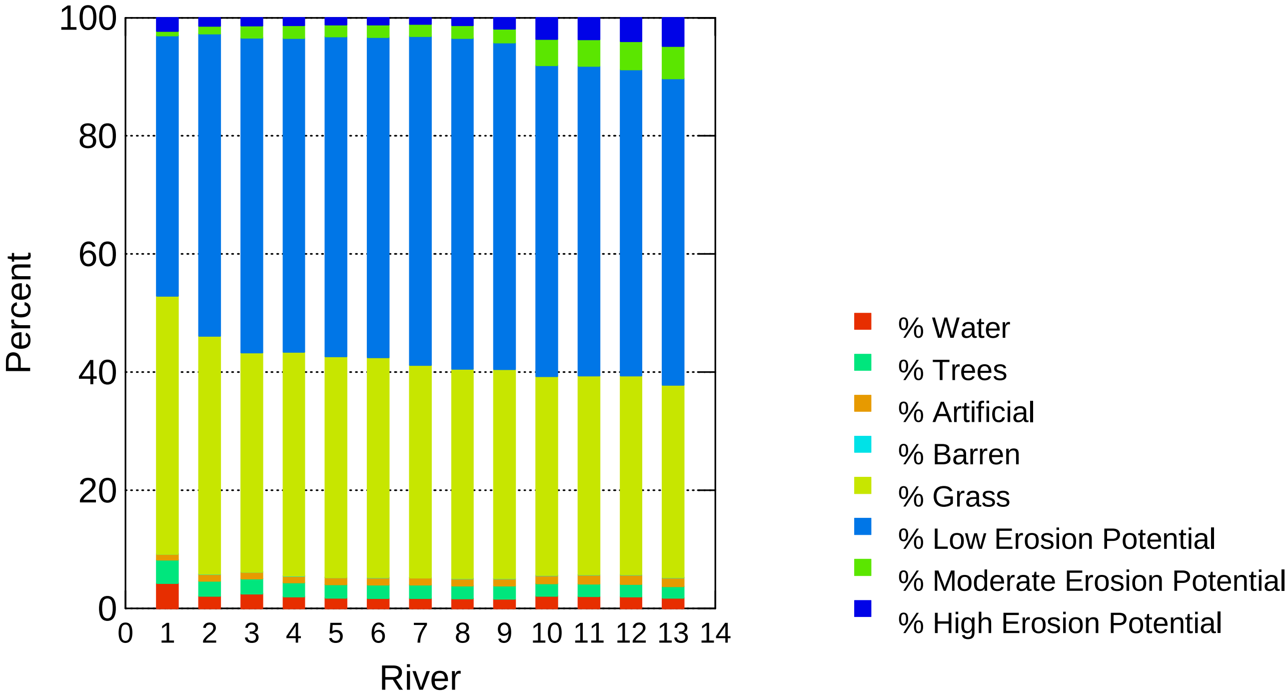


Figure 41. Percent Landuse by River Site

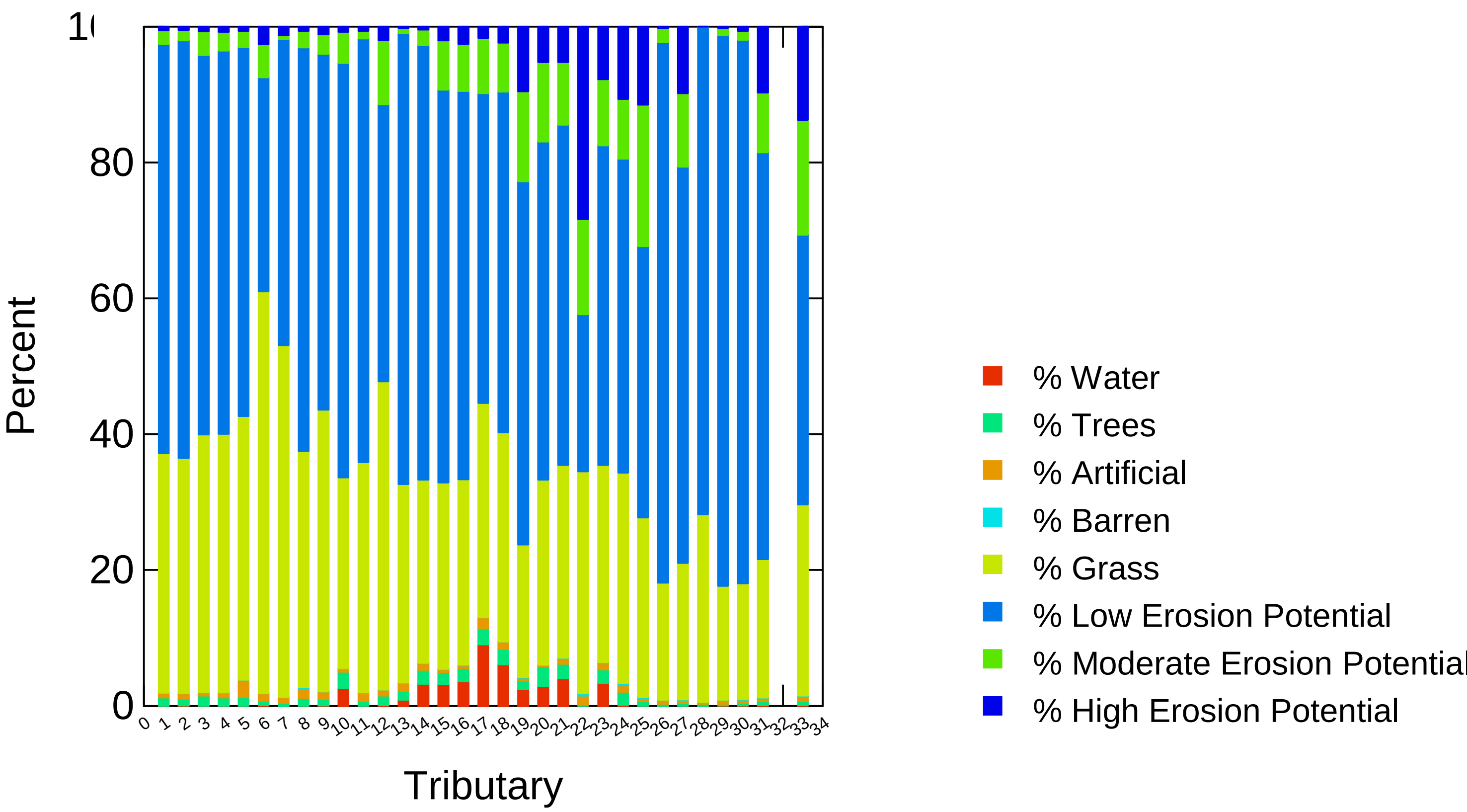


Figure 42. Percent Landuse by Tributary Site

The SDM also produced an erosion potential map (See Figure 43). A shift in erosion potential occurs near the Minnehaha County line. More of the TSS and fecal coliform bacteria problems are in direct relation to these areas.

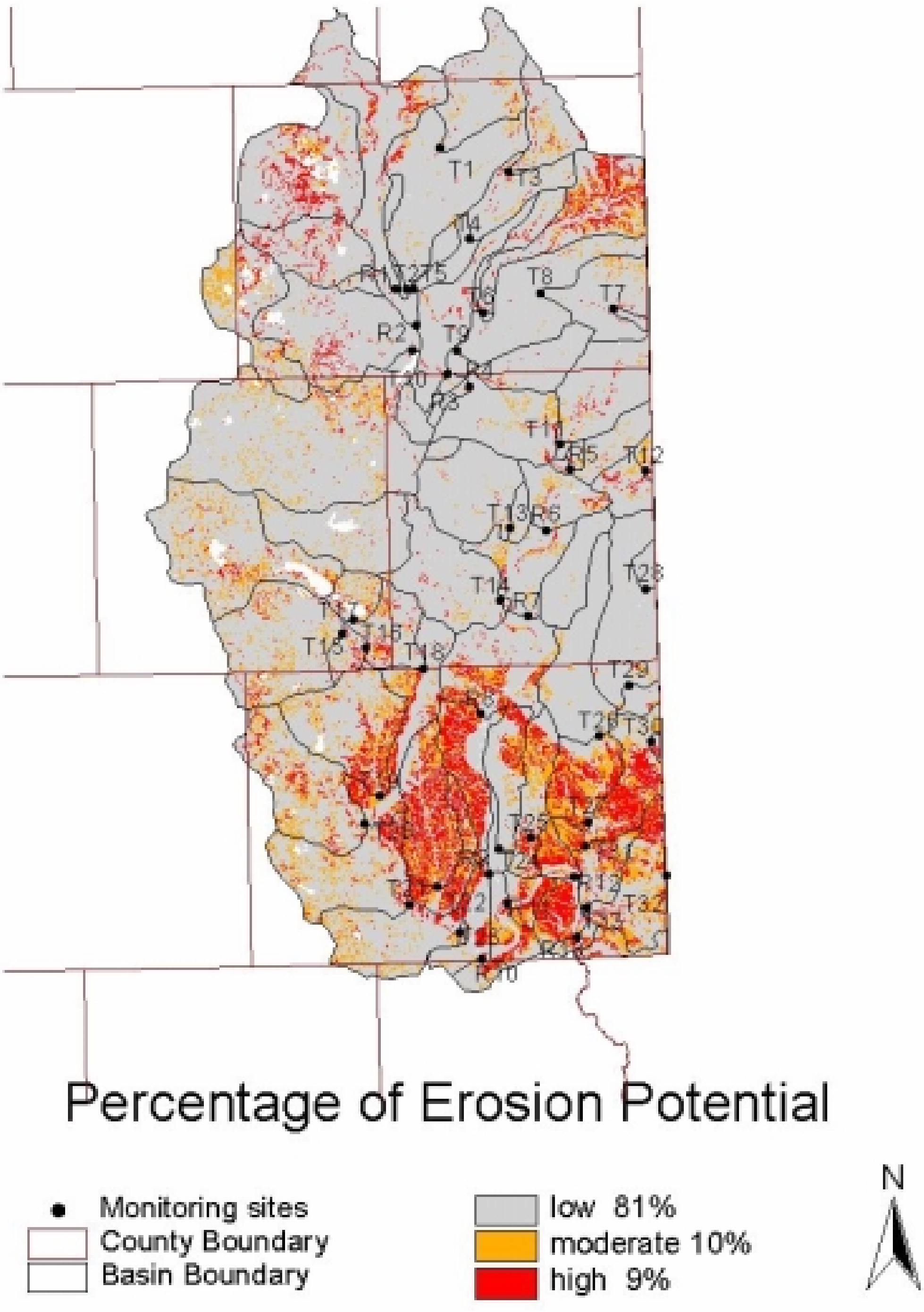


Figure 43. Percent of Low, Moderate, and High Erosion Potential in the CBSRW Study Area

Flow Duration Intervals and Hydrologic Zones

Flow duration intervals divided into hydrologic zones and plotted with seasonal fecal coliform bacteria grab samples were used to find the seasonal loadings and reductions of fecal coliform bacteria at each monitoring site. Target loadings based on the water quality standards and the current load for each monitoring site is shown for each hydrologic zone along with reductions, including a 10 percent margin of safety (MOS) applied. These loads and percent reductions are presented in Appendix BB. Sample data collected during this project, as well as by the DENR were utilized in the calculation of the fecal coliform bacteria.

AGNPS Feedlot Model

AGNPS feedlot model rated 827 feedlots within the Central BSR watershed. Of the 827 feedlots, 254 (31 percent) rated ≥ 50 on a scale from 0 to 100. Higher ratings indicate a greater potential for the operation to pollute near by surface waters. Model outputs from AGNPS are total phosphorus, total nitrogen, and chemical oxygen demand (See Appendix PP). Appendix OO shows the monitoring sites broken out by AGNPS feedlot ratings and also by total number of feedlots.

ANALYSIS AND SUMMARY

SUMMARY OF POLLUTANT LOADINGS BY SUBWATERSHED

Each of the twelve major subwatersheds (Figure 44) is summarized into landuse, water quality, biological and physical, and source linkage. The main focus will be on the five major subwatersheds contributing the majority of the TSS and fecal coliform bacteria – (1) Big Sioux River Direct Drainage Area, (2) Medary/Deer Creek Subwatershed, (3) North Deer/Six Mile Creek Subwatershed, (4) Skunk Creek Subwatershed, and (5) Split Rock Creek Subwatershed.

The water quality assessment in this section (Summary of Pollutant Loadings) is based on the currently assigned beneficial uses and numeric criteria to meet those uses. Based on monitoring results, TSS, fecal coliform bacteria, and DO were the only parameters found not meeting the water quality criteria throughout the watershed. In the Water Quality Goals, the Target Reductions and Priority Management Areas, and also Future Activity Recommendations Section water quality goals were established for all sites not meeting these standards. To meet the water quality goals for fecal coliform bacteria and TSS, streams with less stringent standards and/or those with no standards at all may be identified as priority management areas to achieve the reductions needed to meet the water quality goals of the Central Big Sioux River Watershed.

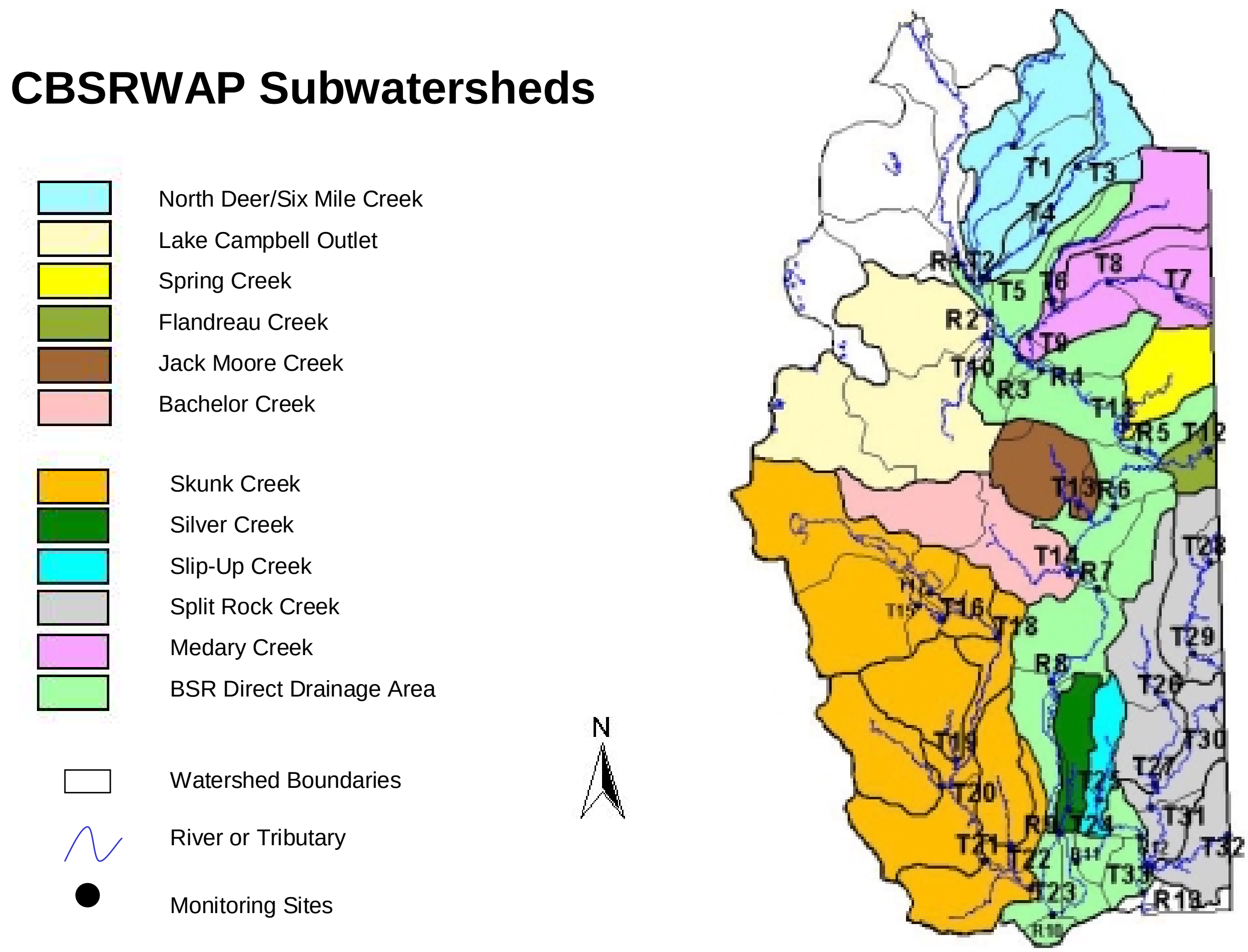


Figure 44. The 12 Major Subwatersheds of the CBSRW Study Area

Big Sioux River Direct Drainage Area

This map (Figure 45) shows the location of the area designated as the Big Sioux River Direct Drainage Area and the potential for erosion.

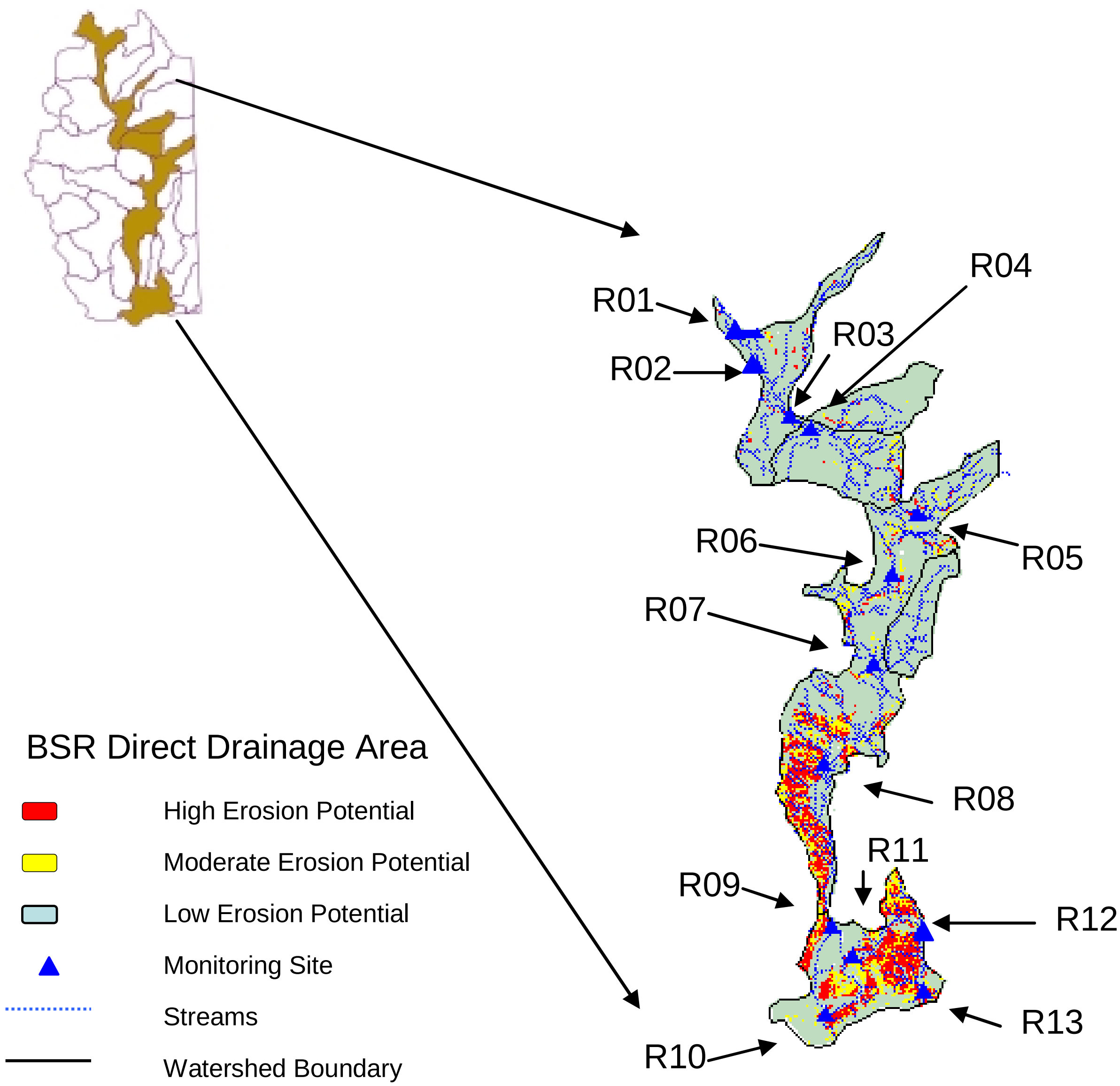


Figure 45. Big Sioux River Direct Drainage Location Map

Land Use

Sites R01 through R05 are located within the Northern Glaciated Plains, while R06 through R13 lie within the Western Cornbelt Plains. Land use in the drainage area is predominantly agricultural (Figure 46). Approximately 57 percent of the area is cropland, such as corn and soybeans, and 37 percent is grassland and pastureland. There are a total of 262 animal feeding operations in the Big Sioux direct drainage area, with approximately 85 percent of the livestock being cattle (See Figure 47).

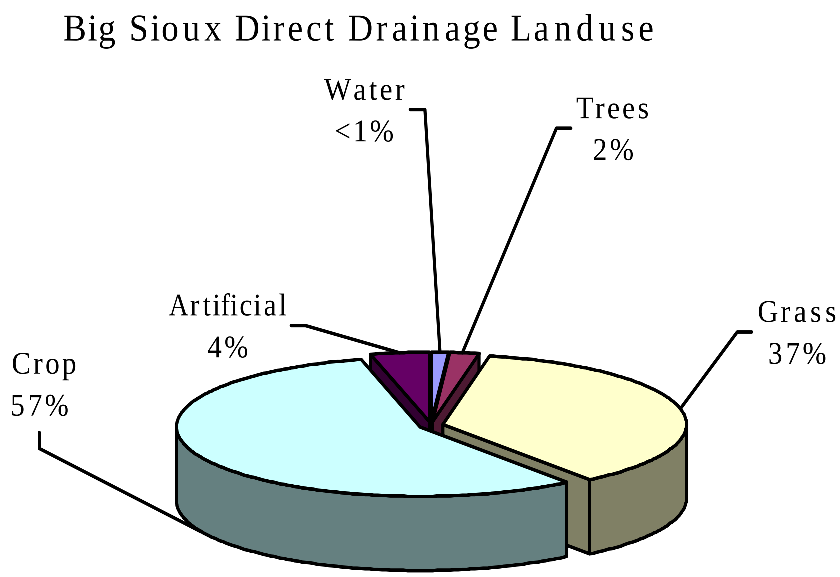


Figure 46. Big Sioux River Direct Drainage Area Landuse

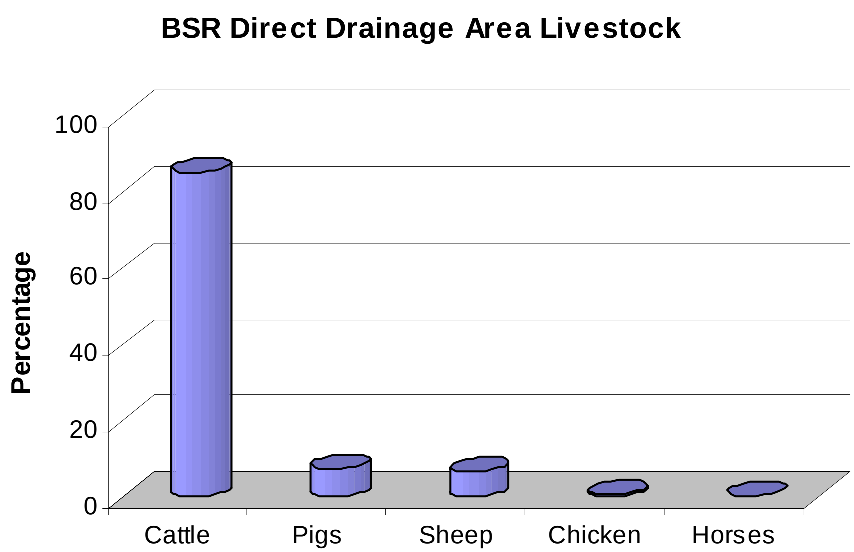


Figure 47. Big Sioux River Direct Drainage Area Livestock

Water Quality Summary

Beneficial uses for river sites R01 to R07 are 1, 5, 8, 9, and 10. River sites R08 to R13 are assigned beneficial uses 1, 5, 7, 8, 9, and 10.

- (1) Domestic Water Supply
- (5) Warmwater Semi-permanent Fish Life Propagation
- (7) Immersion Recreation
- (8) Limited Contact Recreation
- (9) Fish and Wildlife Propagation, Recreation and Stock Watering
- (10) Irrigation

Based on the results from the water quality criteria established by DENR as described in Results section under Water Quality Monitoring, all the river sites (R01-R13) are meeting the water quality criteria for beneficial use (1) Domestic Water Supply.

For beneficial use (5) Warm Water Semi-permanent Fish Life Propagation, all river sites are meeting the criteria as described in the 303(d) waterbody listing for water temperature, DO, pH, and unionized ammonia. River sites R06, R07, R08, and R10 meet the water quality criteria for TSS. However, R01-R05, R09, and R11-R13 do not meet the water quality criteria for TSS (See Figures 48 and 49).

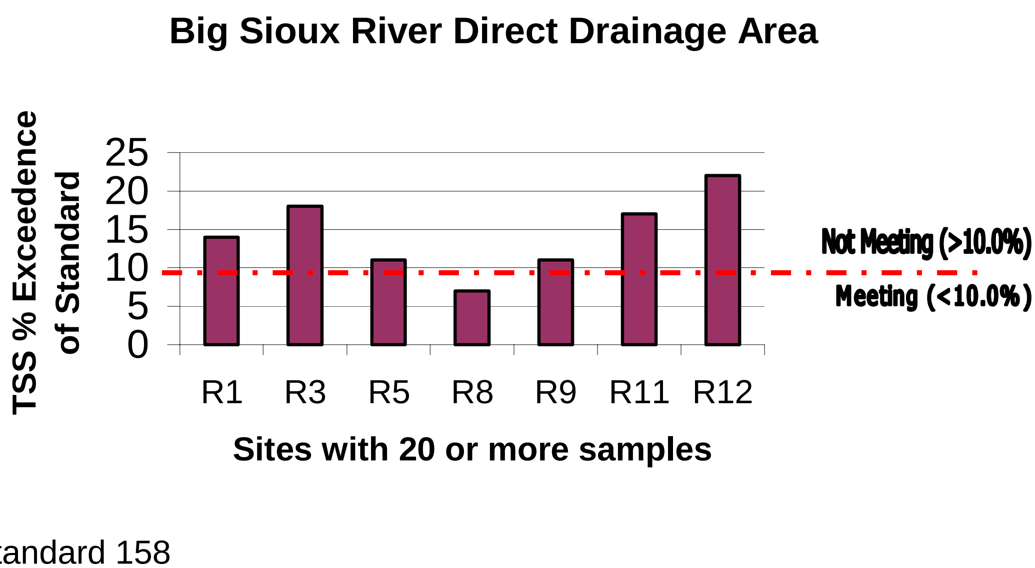


Figure 48. TSS Percent Exceedence at Standard 158 mg/L for Sites with 20 or More Samples

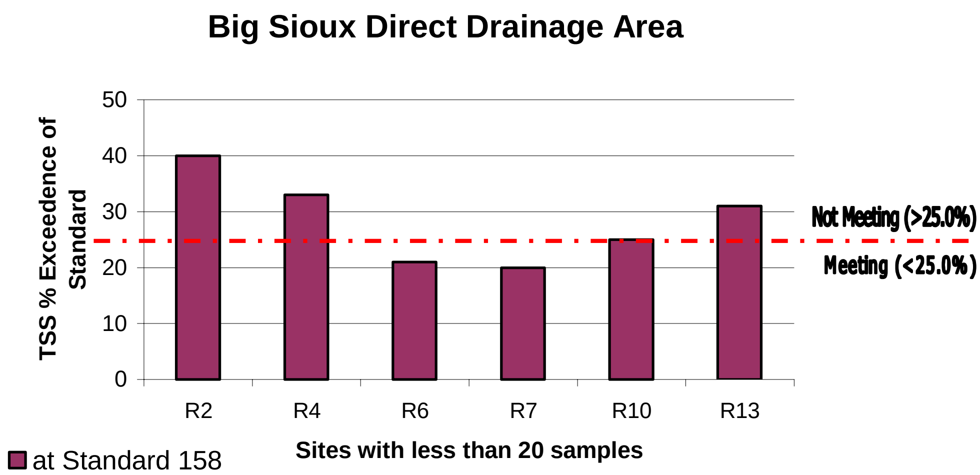


Figure 49. TSS Percent Exceedence at Standard 158 mg/L for Sites with Less Than 20 Samples

Based on FLUX model results, Figure 50 shows the estimated TSS loadings of R01-R13 as compared to the allowable load of 158 mg/L. Scatterplots of the TSS grab samples are shown in Figures 51 and 52.

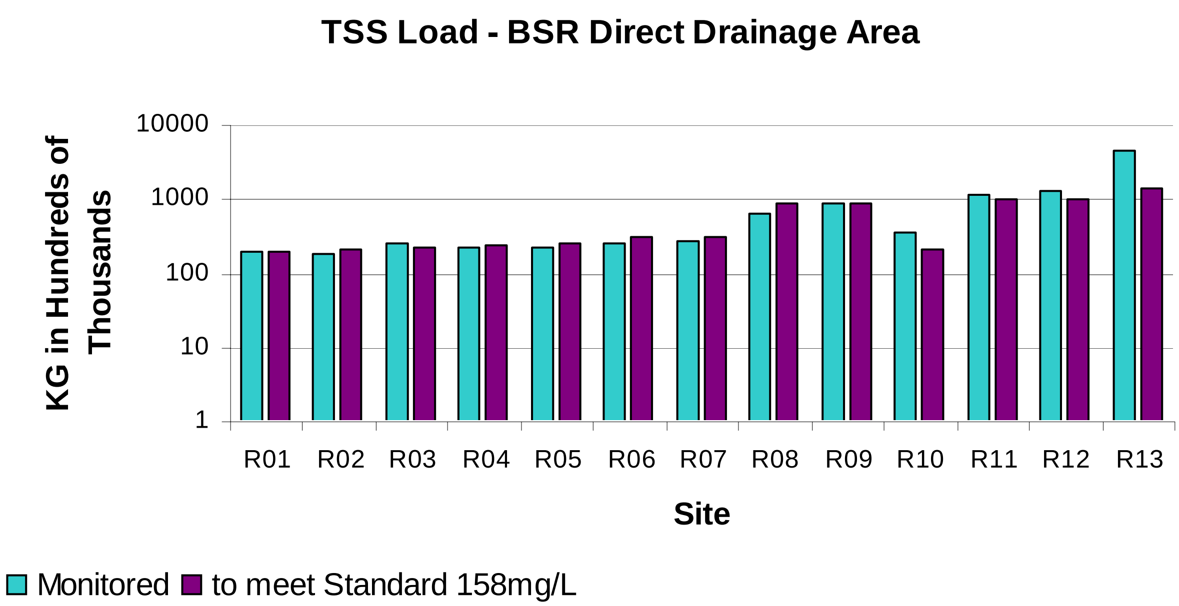


Figure 50. TSS in kg Monitored vs the Standard for the BSR Direct Drainage Area

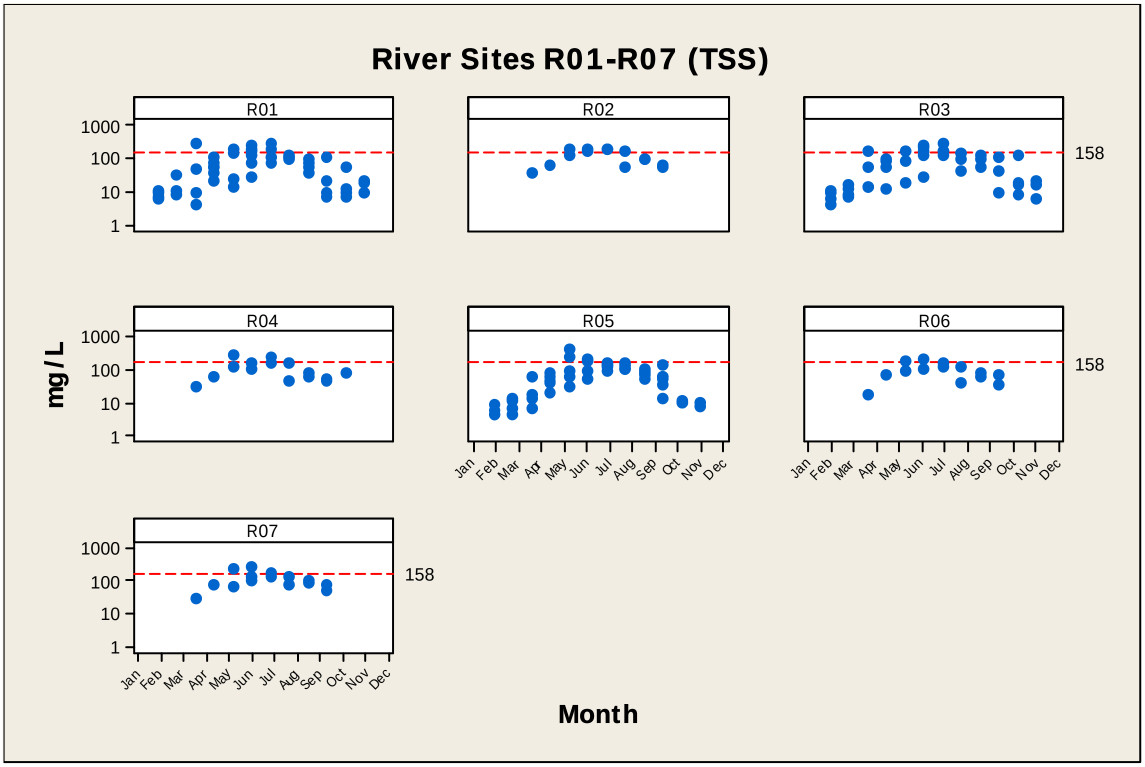


Figure 51. Scatterplot of TSS Grab Samples for River Sites (R01-R07)

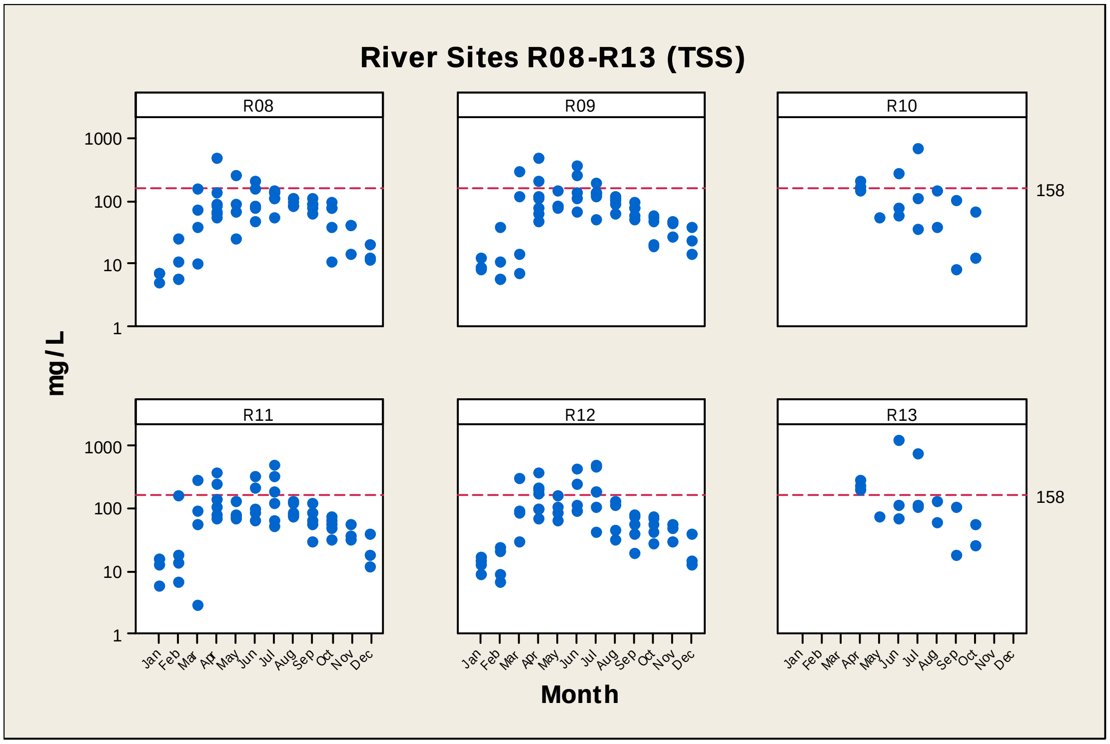


Figure 52. Scatterplot of TSS Grab Samples for River Sites (R08-R13)

Additionally, linear regressions were completed for each monitoring location to find the relationship between TSS and NTU (See Figure 53). R^2 ranged from 0.672 at Site R09 to 0.9839 at Site R01.

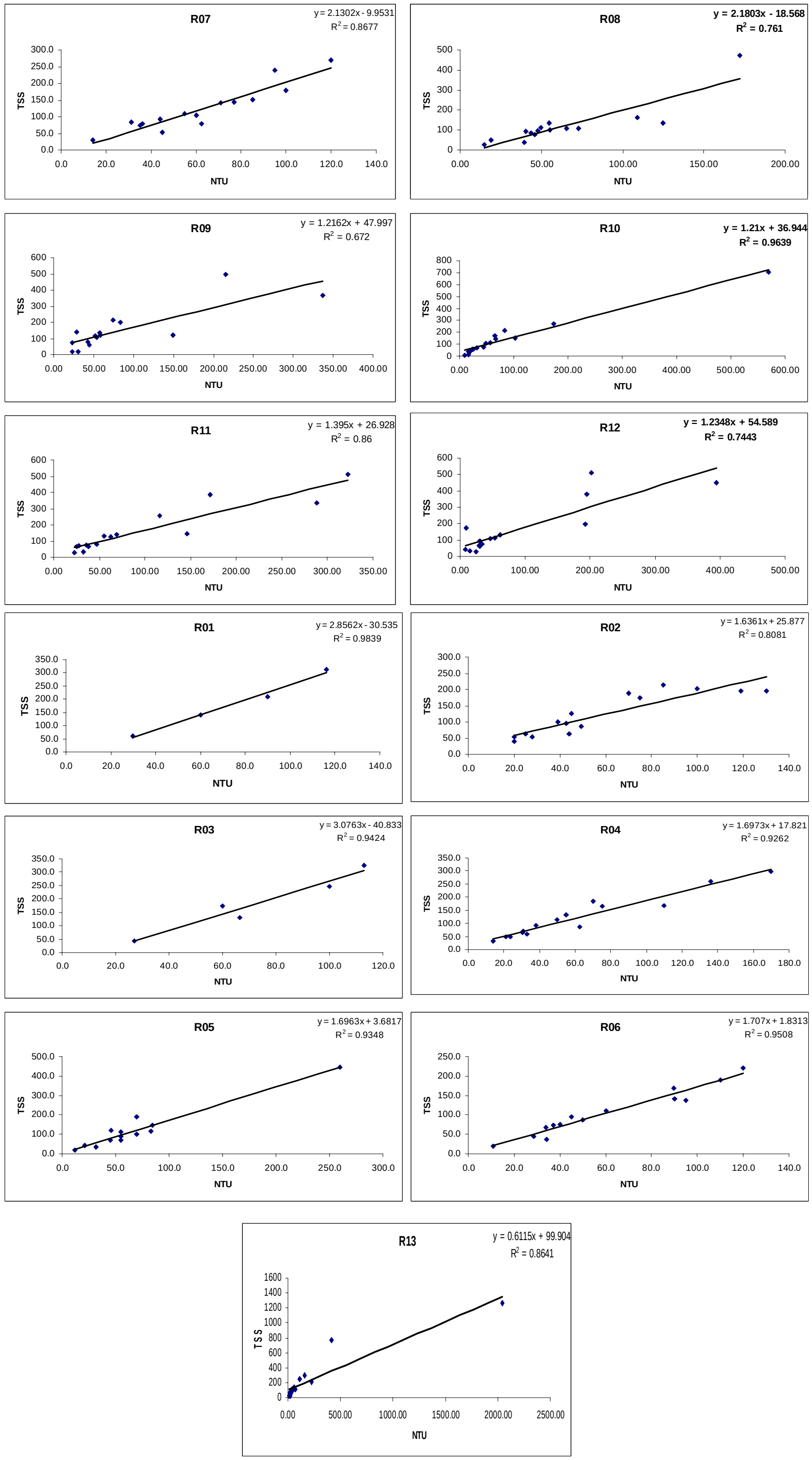


Figure 53. Comparison of TSS and Turbidity for Sites R01 through R13

Beneficial use (7) Immersion Recreation is assigned to river sites R08-R13. The numeric criteria for fecal coliform bacteria are 400 cfu/100mL and for DO it is ≥ 5 mg/L. These sites are meeting the water quality criteria for DO. However, all are not meeting the water quality criteria for fecal coliform bacteria.

Beneficial use (8) Limited Contact Recreation is assigned to river sites R01-R13. However, beneficial use (7) supersedes beneficial use (8) when both are applied to the same monitoring location. Thus, only river sites R01-R07 were assessed for beneficial use (8). The numeric criteria for fecal coliform bacteria are 2000 cfu/100mL and for DO it is ≥ 5 mg/L. Based on this, all are meeting the water quality criteria for DO and for fecal coliform bacteria. (See Figure 54).

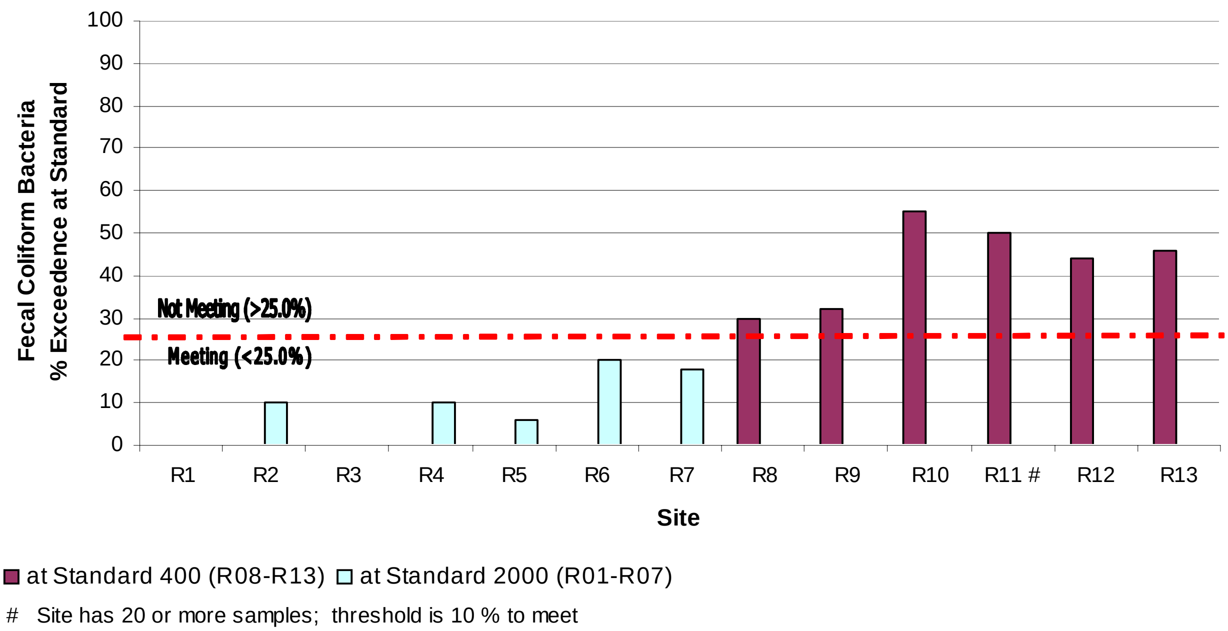


Figure 54. Fecal Coliform Bacteria Percent Exceedence at Standard 400 cfu/100mL (R08-R13) and at Standard 2000 cfu/100mL (R01-R07)

Based on average daily discharge and seasonal grab sample data graphs were constructed showing the monitored loadings and the allowable target loads at either the 400 cfu/100mL or the 2000 cfu/100mL water quality standard, within each of the five hydrologic conditions (See Figure 55).

BSR Direct Drainage Area

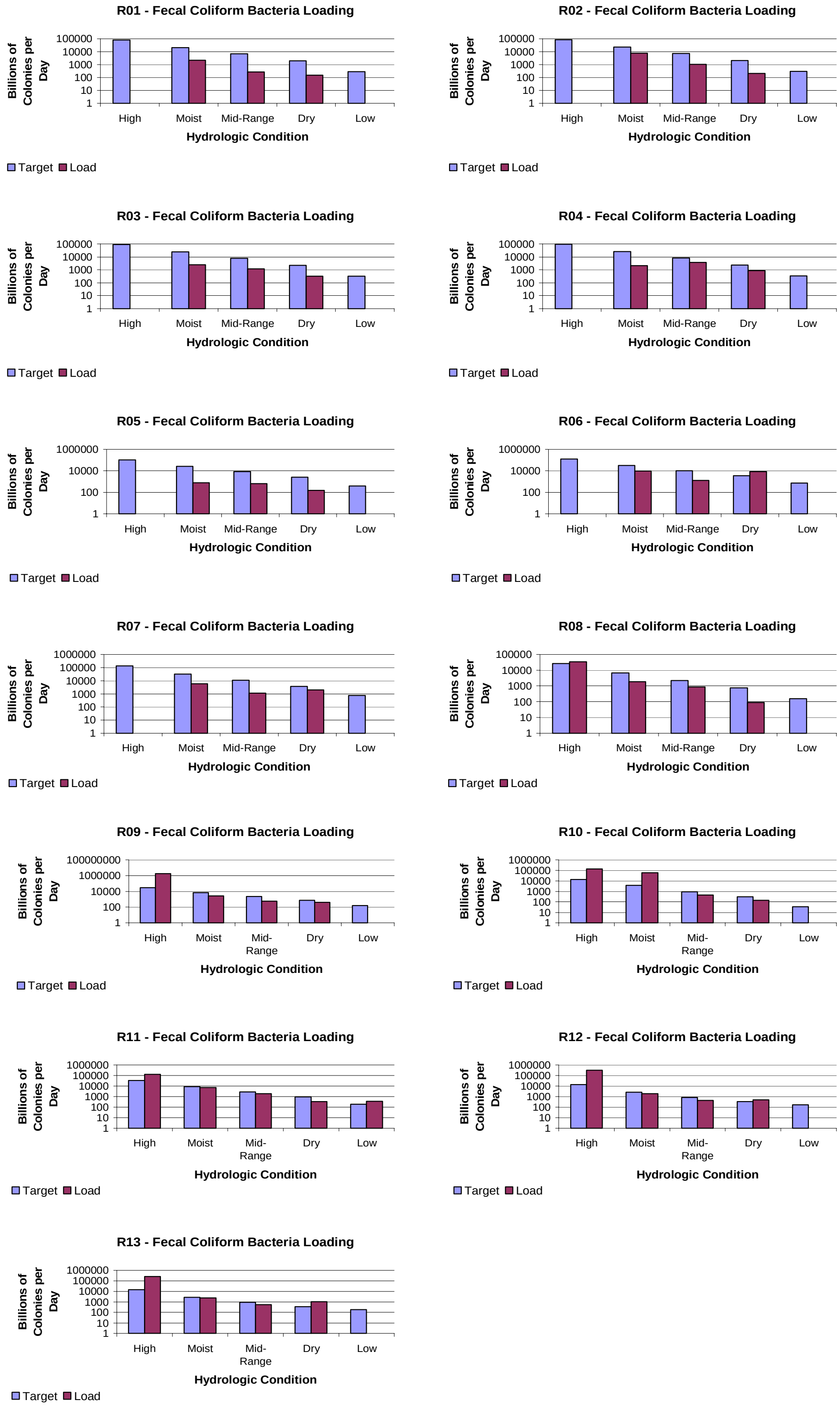


Figure 55. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the BSR Direct Drainage Area

Scatterplots of the fecal coliform bacteria grab samples are shown in Figures 56 and 57.

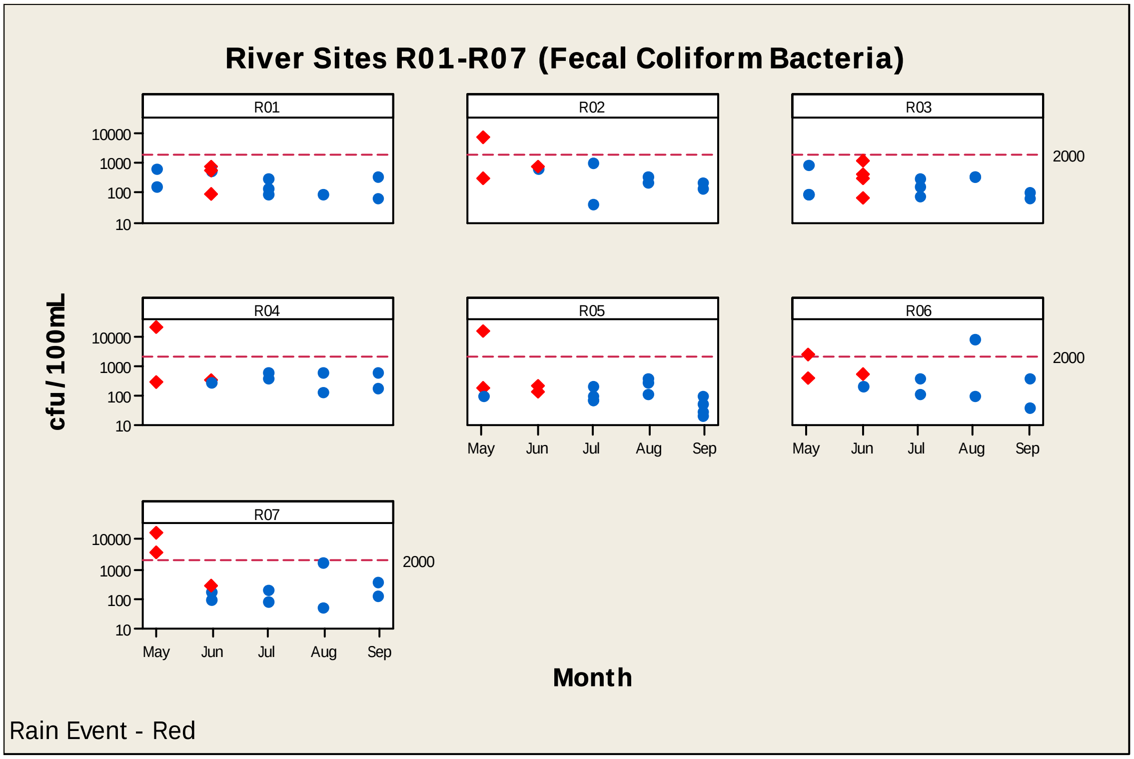


Figure 56. Scatterplot of Fecal Coliform Bacteria Grab Samples for River Sites (R01-R07)

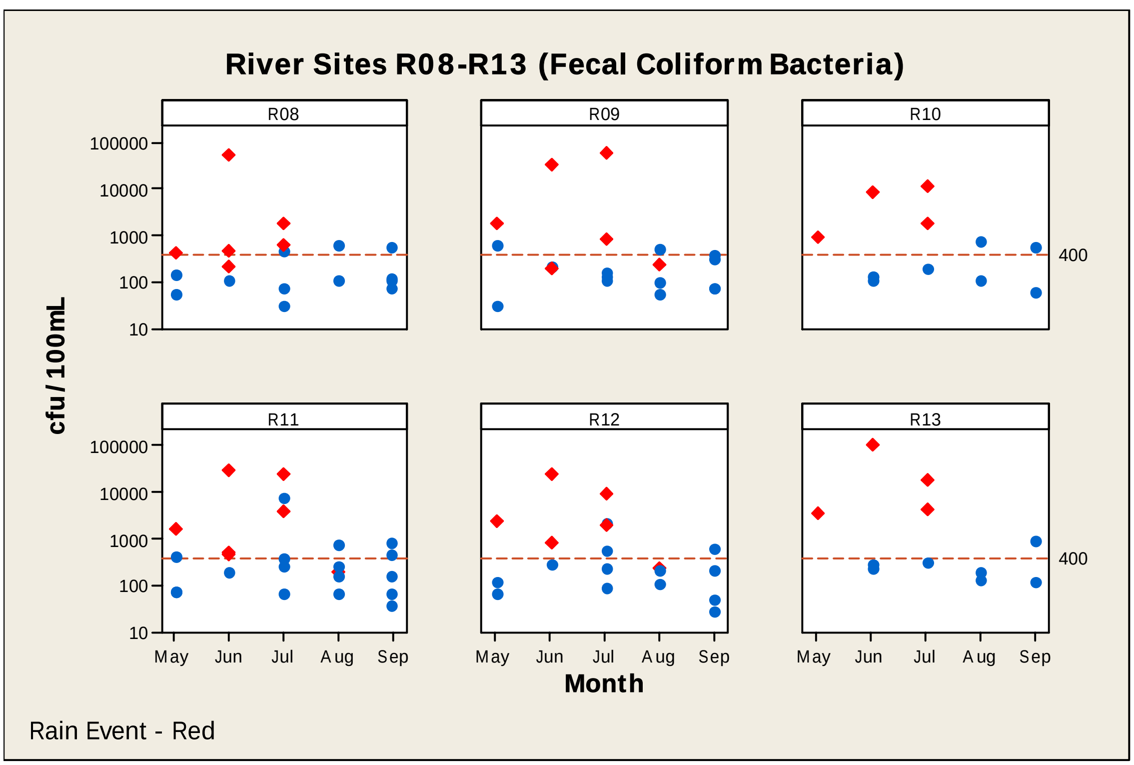


Figure 57. Scatterplot of Fecal Coliform Bacteria Grab Samples for River Sites (R08-R13)

Trends in fecal coliform bacteria are shown in Figures 58, 59, 60, and 61. DENR ambient grab sample data for R03 (WQM2), R08 (WQM3), and R11 (BS29) was used to construct these figures. The seasonal (May through Sept) medians for each year, from 1976 to 2003, were calculated. The statistical significance of a trend was determined to occur at an R^2 value of 0.25 or greater, due to the large sample size of 28 years of data.

Figure 58 does not show a significant positive or negative trend in fecal coliform bacteria, $R^2 = 0.0172$, for monitoring site R03. This area is meeting the water quality criteria for fecal coliform bacteria. However there is some concern when looking at the past 10 years of fecal coliform data. Figure 59 plots the past 10 years of yearly seasonal medians of fecal coliform bacteria. The $R^2 = 0.4793$ indicates an increasing trend in this area.

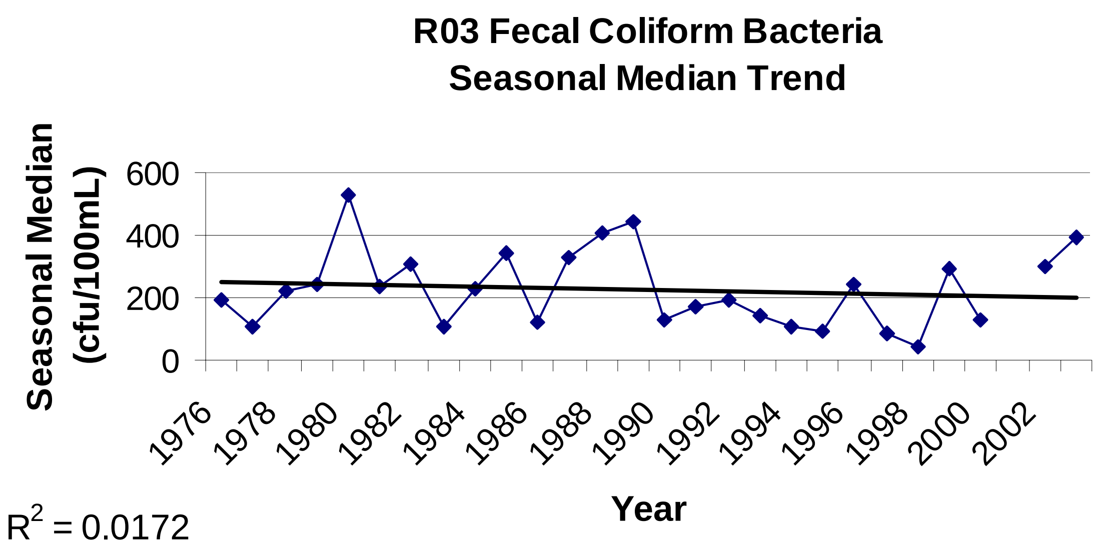


Figure 58. 28-Year Trend (1976-2003) of Yearly Seasonal Medians of Fecal Coliform Bacteria for R03

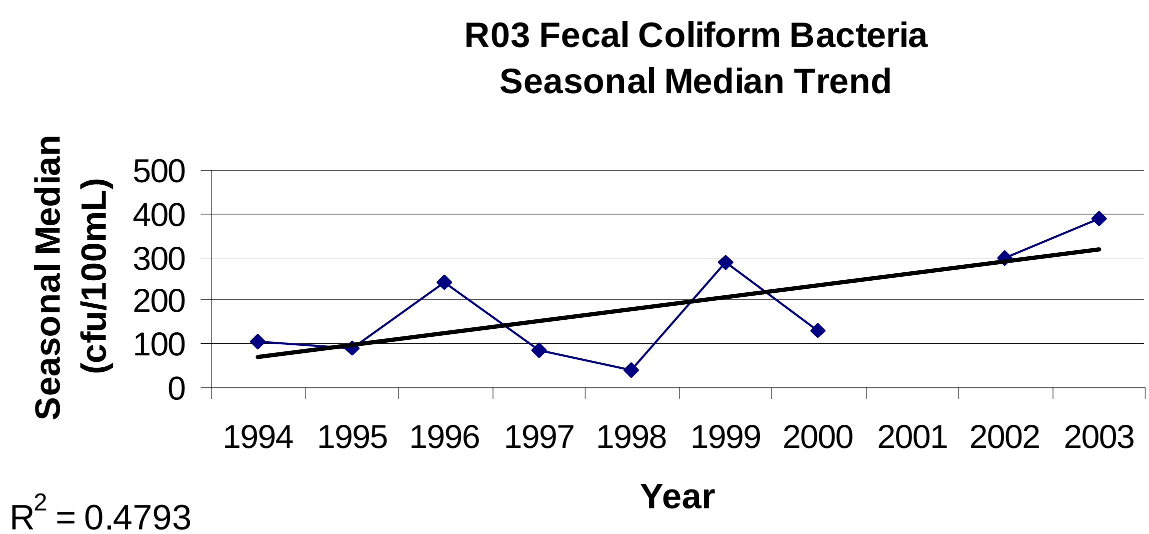


Figure 59. 10-Year Trend (1994-2003) of Yearly Seasonal Medians of Fecal Coliform Bacteria for R03

Figure 60 does not show a significant positive or negative trend in fecal coliform bacteria, R2 = 0.0566, for monitoring site R08. This area is not meeting the water quality criteria for fecal coliform bacteria.

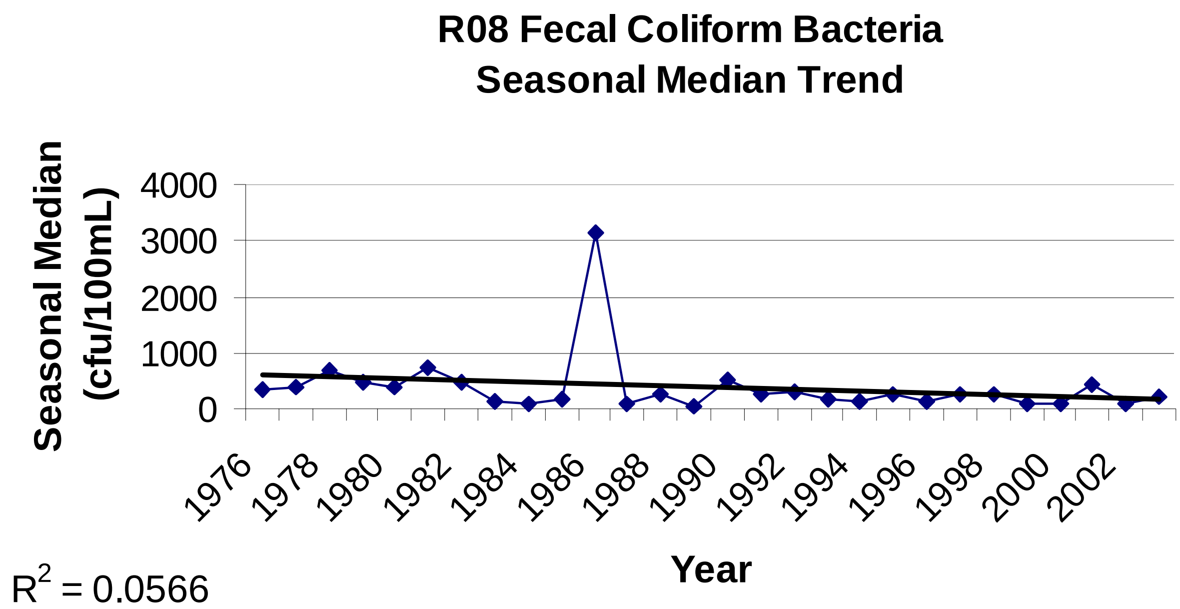


Figure 60. 28-Year Trend (1976-2003) of Yearly Seasonal Medians of Fecal Coliform Bacteria for R08

Figure 61 shows a decreasing trend in fecal coliform bacteria, R^2 = 0.4618, for monitoring site R11. Although there seems to be a decrease in fecal coliform bacteria, this area is still not meeting water quality criteria.

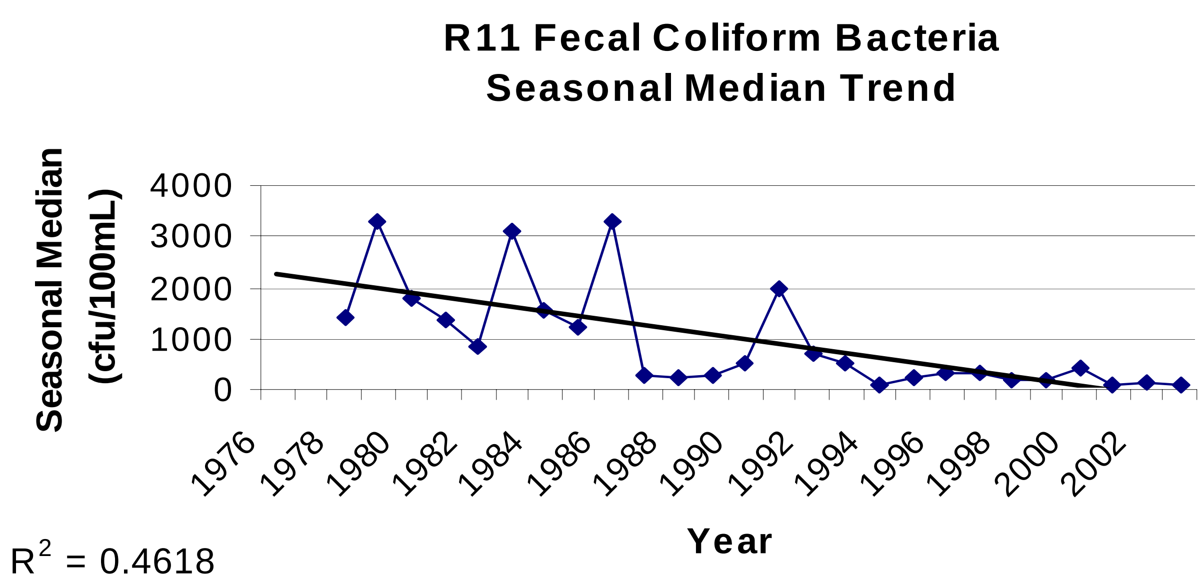


Figure 61. 28-Year Trend (1976-2003) of Yearly Seasonal Medians of Fecal Coliform Bacteria for R11

All the river sites (R01-R13) are meeting water quality criteria for beneficial use (9) Fish and Wildlife Propagation, Recreation, and Stock Watering and (10) Irrigation.

The following table (Table 34) summarizes the ranges of fecal coliform bacteria (cfu/100mL), ranges of TSS (mg/L), and the percent exceedences. It also shows the summer mean of total PO4 (mg/L) for each river monitoring site.

Table 34. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 for River Sites

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
R01	60-690	0	4-314	14	0.33
R02	40-6800	10	38-213	40	0.43
R03	60-1200	0	4-326	18	0.51
R04	130-20000	10	33-299	33	0.50
R05	50-15000	11	0-444	11	0.45
R06	40-8500	20	20-220	21	0.37
R07	50-17000	18	30-270	20	0.39
R08	20-52000	30	5-3300	7	0.35
R09	50-56000	50	6-496	11	0.41
R10	60-11000	55	8-703	25	0.37
R11	160-31000	60	3-513	17	0.89
R12	50-26000	44	6-513	22	0.97
R13	130-117000	46	19-1264	31	0.97

Total Phosphorus Summary

The summer mean concentrations for total phosphorus for sites R01-R05 exceed the ecoregion mean of 0.25 mg/L. The summer mean concentrations of total phosphorus for sites R06-R13 exceed the ecoregion mean of 0.30 mg/L. The summer mean concentrations for total phosphorus of sites R11, R12, and R13 are three times greater than the WCBP ecoregion mean of 0.30 mg/L (Fandrei et al. 1988). The higher numbers can be attributed to sources such as livestock waste, streambank erosion, commercial fertilizers, construction site erosion, and/or urban stormwater runoff.

TSS Summary

The LMU's were grouped together to form the twelve major sub-basins of the CBSRW (See Figure 44). A mass balance approach was used to determine the relative percent (contribution) of TSS loading to the Big Sioux River (R13) and within subwatersheds with multiple monitoring sites. The following pie charts (Figure 62 and Figure 63) illustrate the percent contributions of TSS of the subwatersheds and the direct drainage to the Big Sioux River. Note, to make equal monthly comparisons, the analysis of Figure 63 (R01-R08) used the sampling months of Jul 1999 to Oct 1999 and Mar 2000 to Oct 2000. The analysis for Figure 62 (R08-R13) used the sampling months of Jul 2000 to Oct 2000 and May 2001 to Oct 2001.

The data represents a breakdown of the mass loading of TSS at R13. Total mass was calculated using the FLUX model, insuring sample and flow dates fell within the same time frame. Working up from Site

R13, the TSS load from each upstream site (including its watershed) was isolated by subtracting off all other upstream site or watershed contributions. This site-specific load was then divided by the mass load calculated at R13 (the lower most monitoring site) to obtain the percent contribution of that particular watershed. See Appendix MM for pollutant load summary calculations.

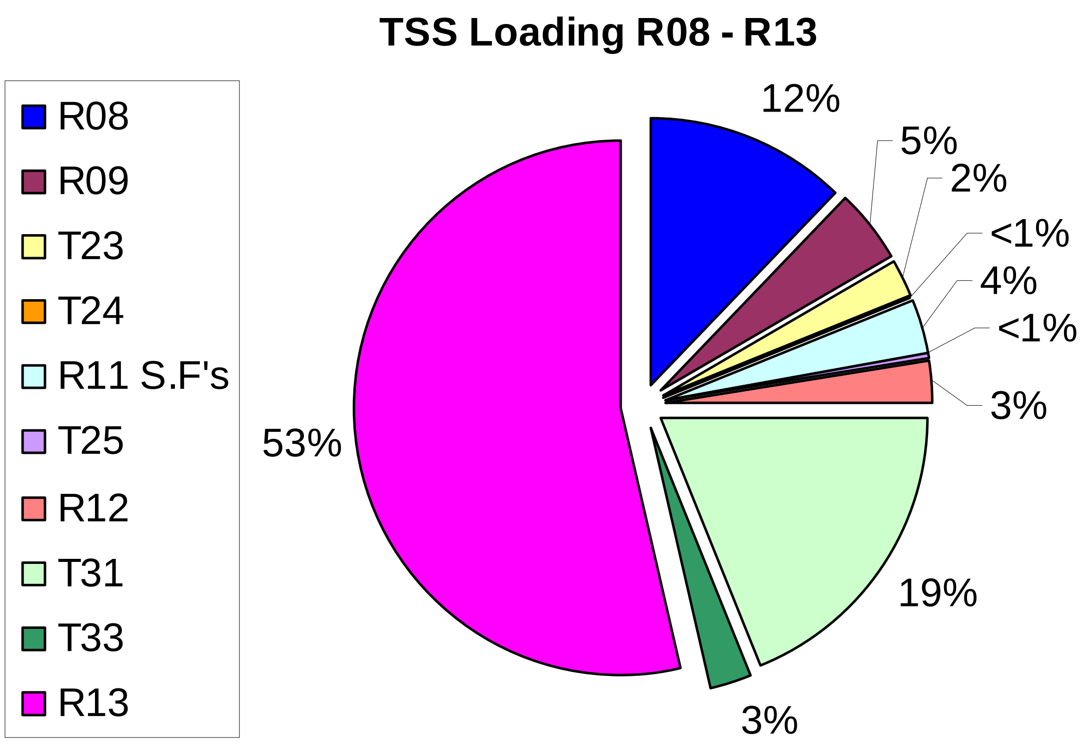


Figure 62. Percent Contributions of TSS Loading Between R08 and R13

Based on the mass-balance approach, Figure 62 represents the percentage of contribution from R08 at Dell Rapids to R13, just downstream of Sioux Falls, near Gitchie Manitou Park. As shown in Figure 62, the 53 percent piece of the pie represents a watershed area that falls below R12, below T31 and T33, and above R13 consisting of an area of approximately 23,897 acres which yields 20 tons of sediment per acre for the months that were monitored (See Figure 62a). This is by far the most significant sediment load occurring with in the project area.

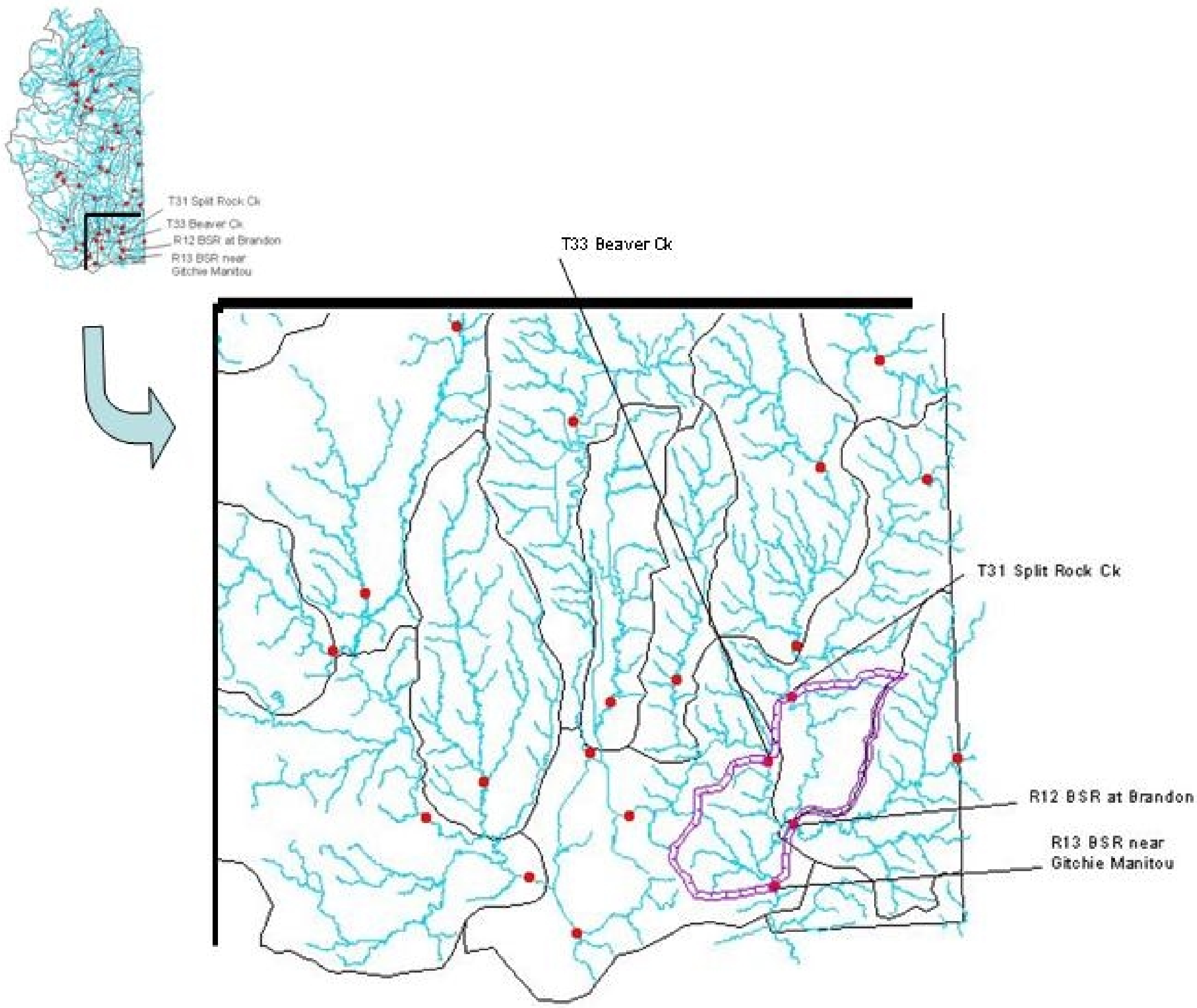


Figure 62a. Area Contributing the Most Significant TSS Loading in the Study Area

The second highest sediment loading, of 19 percent, occurred above T31 in the Split Rock Creek Subwatershed consisting of an area of approximately 304,000 acres which yields 0.34 tons of sediment per acre for the months that were monitored (See Figure 62b).

The watershed area above Dell Rapids (R08) represents 12 percent of the total sediment load in the project area, with approximately 2,058,880 acres of land yielding 0.04 tons of sediment per acre for the months that were monitored.

The area above R09 and below R08 represents five percent of the total sediment load, with approximately 22,338 acres of land yielding 1.2 tons of sediment per acre.

The area above R11, below R09, and including R10 representing the area of Sioux Falls, excluding Skunk Creek Subwatershed (T23) and Silver Creek Subwatershed (T24) represents four percent of the total sediment load, with approximately 35,176 acres of land yielding 0.54 tons of sediment per acre.

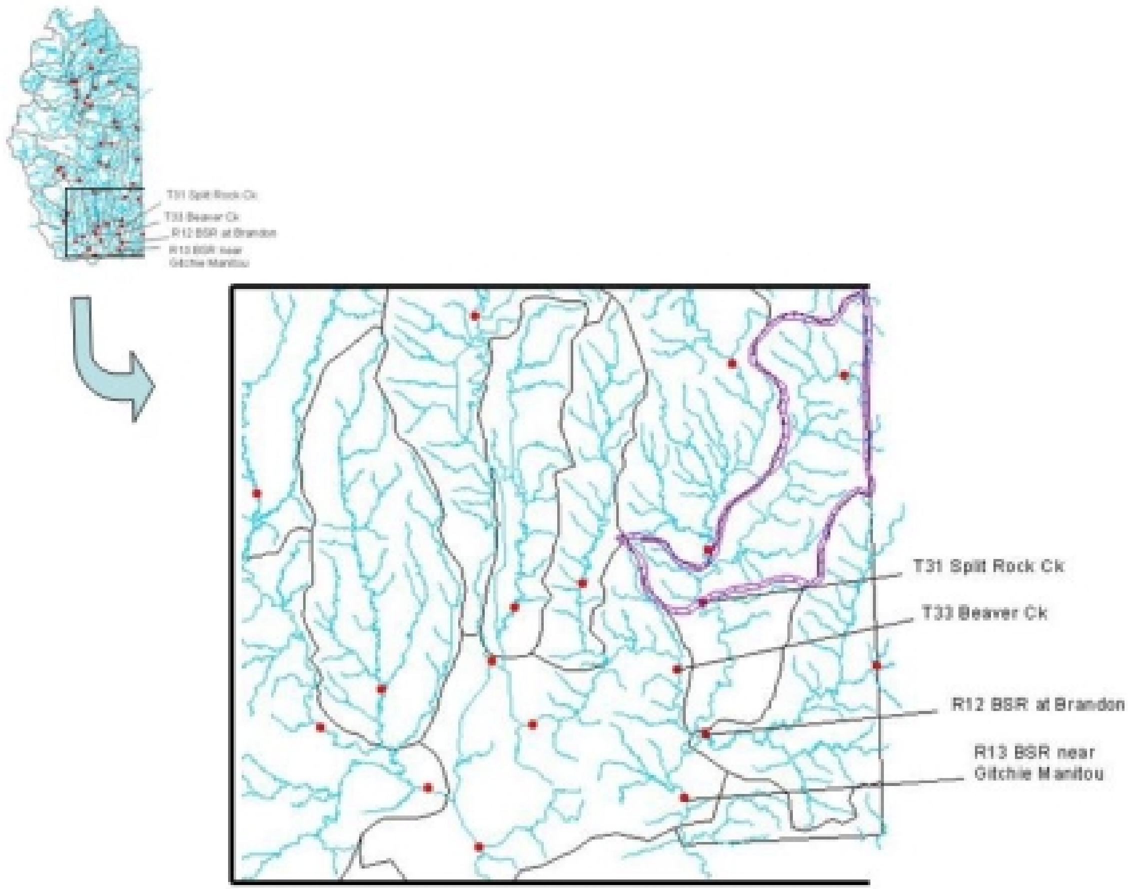


Figure 62b. Area Contributing the Second Highest Loading of TSS within the Study Area

The area above R12 below R11 and T25 represents three percent of the sediment load, with approximately 19,221 acres of land yielding 0.79 tons of sediment per acre.

The sediment loading above T23 in the Skunk Creek Subwatershed is two percent and consisted of an area of approximately 39,264 acres which yielded 0.03 tons of sediment per acre for the months that were monitored.

The area above T33 represents three percent of the total sediment load, with approximately 27,184 acres of the watershed within the boundaries of South Dakota yielding 0.15 tons per acre for the months that were monitored. Approximately 60 percent more of this subwatershed resides within Minnesota.

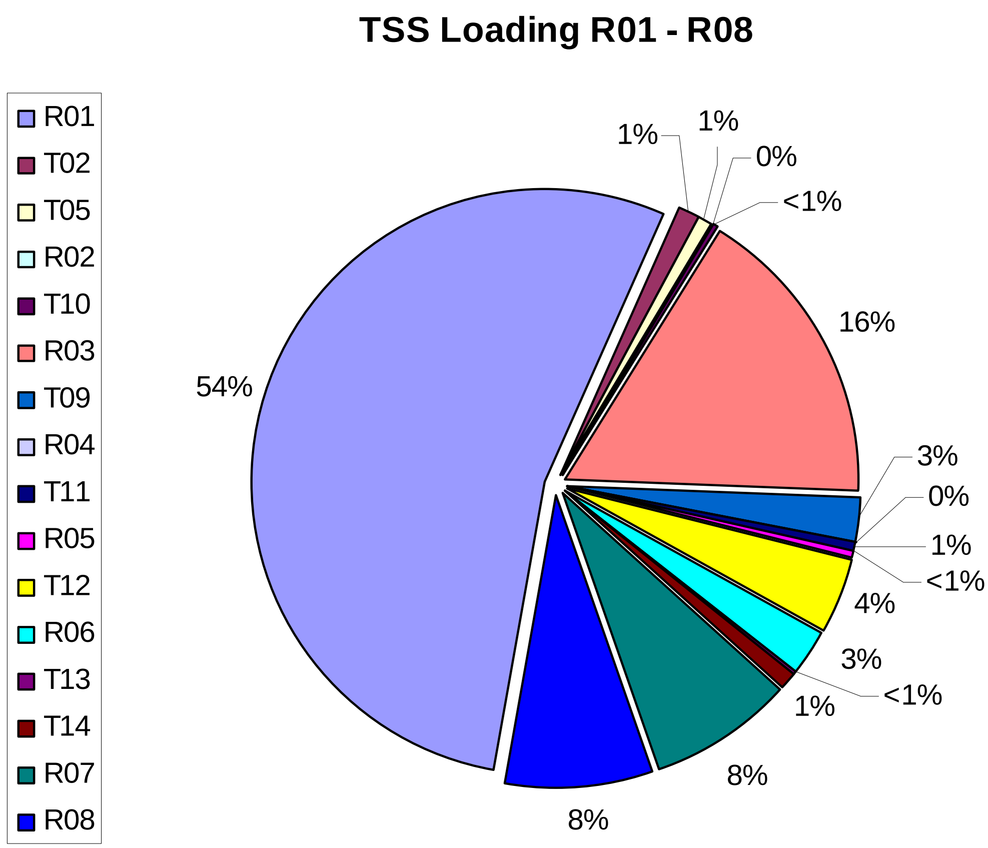


Figure 63. Percent Contributions of TSS Loading Between R01 and R08

Figure 63 correspond to all the contributions that make up the 12 percent (area above Dell Rapids), as previously presented in Figure 62.

As stated earlier, the watershed above Dell Rapids (R08) represents 12 percent of the total sediment load in the project area. Of this 12 percent, 54 percent occurred above R01 (the northern-most site in the study area), which lies outside of the study area. This 54 percent constitutes approximately seven percent of the total sediment contribution at R13. Figure 64 depicts the pie chart breakdown.

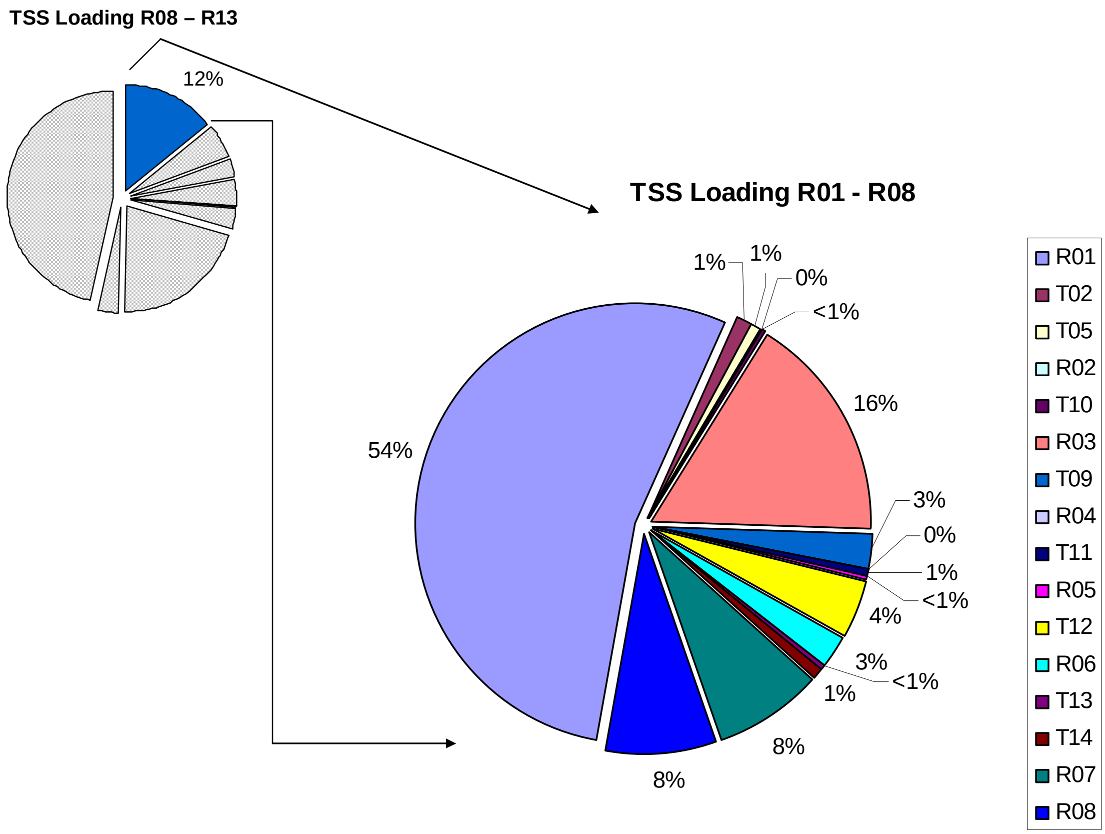


Figure 64. Breakout of the 12 Percent of TSS Loadings Occurring Above Dell Rapids

The sediment loading below R02 and T10, and above R03 is 16 percent, which is two percent of the total sediment contribution at R13. This consisted of an area of approximately 91,893 acres which yielded 0.07 tons of sediment per acre for the months that were monitored.

The sediment loading above R07 is eight percent of the 12 percent pie piece from Figure 61. This is one percent of the total sediment contribution at R13 and comprises an area of approximately 25,539 acres which yielded 0.13 tons of sediment per acre for the months that were monitored.

The sediment loading above R08 is eight percent of the 12 percent pie piece from Figure 61. This is one percent of the total sediment contribution at R13 and comprises an area of approximately 54,936 acres which yielded 0.06 tons of sediment per acre for the months that were monitored.

The remaining pie pieces from both Figures 62 and 63, which includes sites T02, T05, T10-T14, T24, T25, R02, R04, R05 and R06, accounts for approximately two percent of the remaining sediment load total at R13.

Trends in TSS are shown in Figures 65, 66 and 67. DENR ambient grab sample data for R03 (WQM2), R08 (WQM3), and R11 (BS29) was used to construct these figures. The annual averages for each year, 1975 to 2003, were calculated. The statistical significance of a trend was determined to occur at an R^2 value of 0.25 or greater, due to the large sample size of 29 years of data.

Figure 65 does not show a significant positive or negative trend in TSS, $R^2 = 0.0575$, for monitoring site R03. This area is not meeting the water quality criteria for TSS.

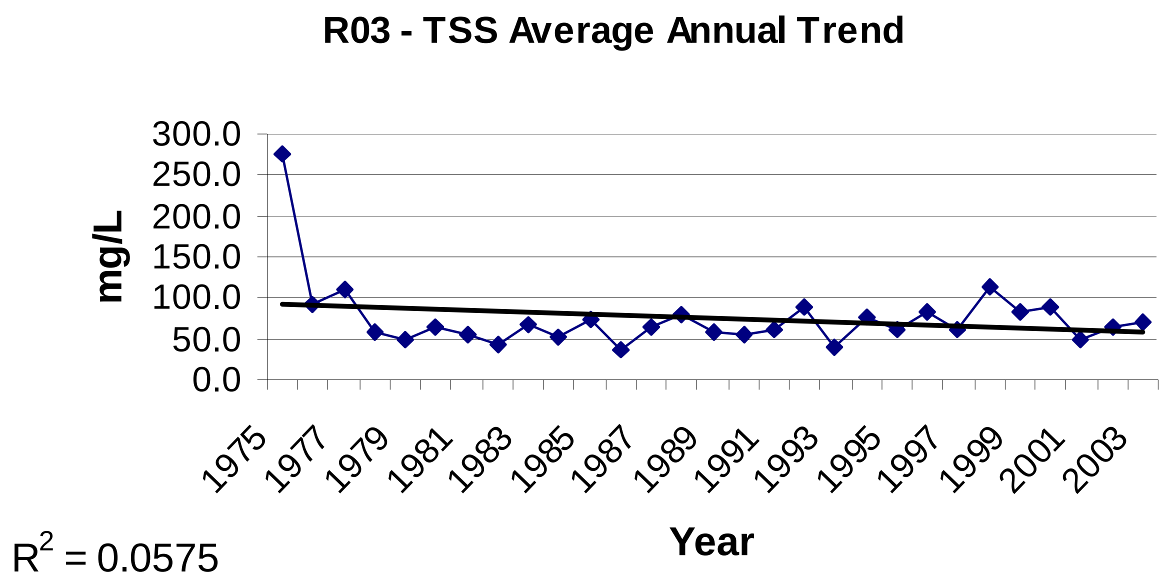


Figure 65. TSS 29-Year Trend (1975-2003) of Annual Averages for R03

Figure 66 does not show a significant positive or negative trend in TSS, $R^2 = 0.0073$, for monitoring site R08. This area is meeting the water quality criteria for TSS.

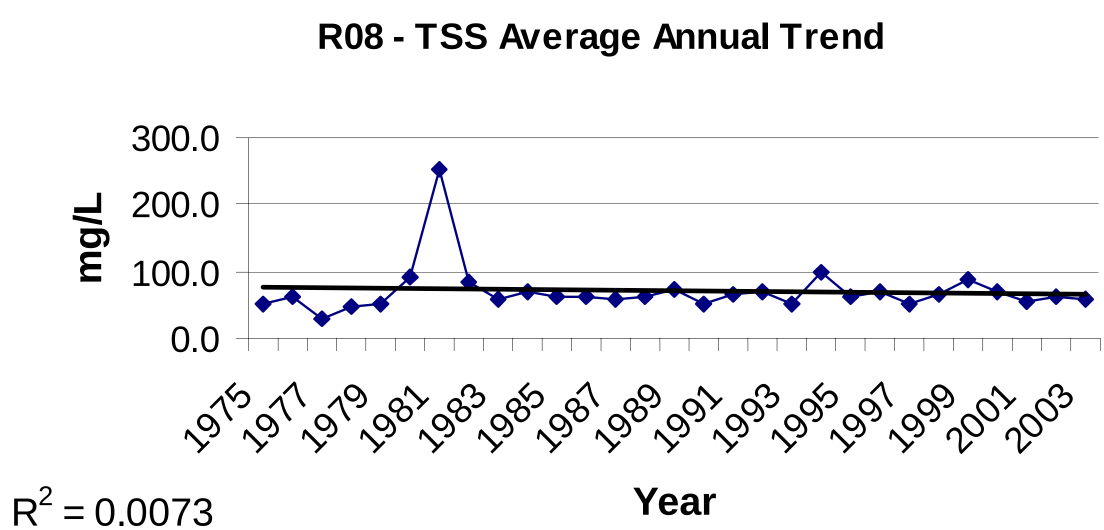


Figure 66. TSS 29-Year Trend (1975-2003) of Annual Averages for R08

Figure 67 shows and increasing trend in TSS, $R^2 = 0.2589$, for monitoring site R11. In addition, this area is not meeting the water quality criteria for TSS.

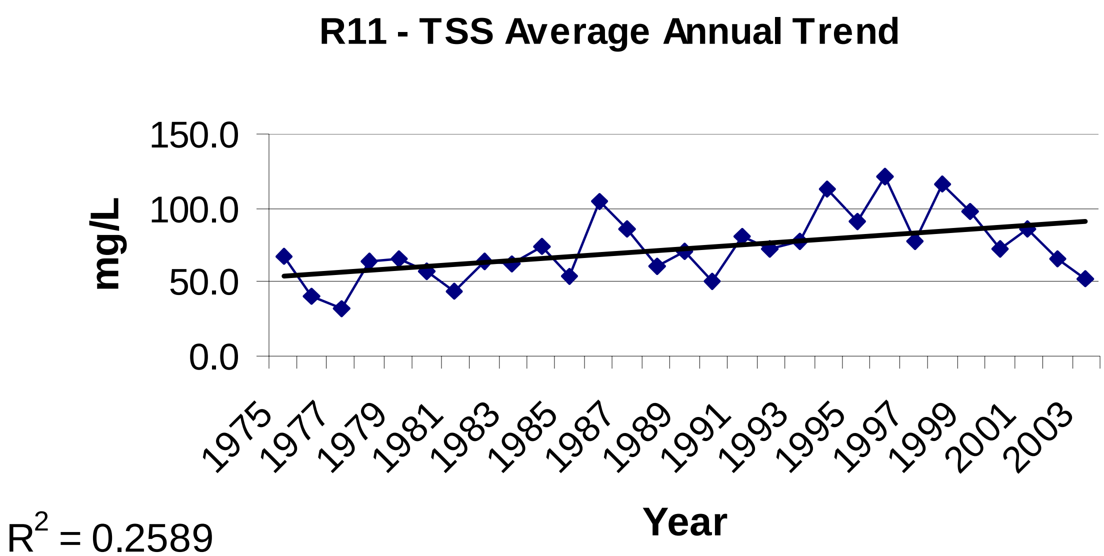


Figure 67. TSS 29-Year Trend (1975-2003) of Annual Averages for R11

Biological and Physical Habitat Summary

Fish and physical habitat measurements were not completed on any of the Big Sioux River mainstem sites. The following table summarizes the scores and suggested impairment based on the macroinvertebrate data. Score sheets for each site can be found in Appendix N.

Sites R06, R10 and R12 are minimally impaired based on the low numbers of tolerant and very tolerant organisms. Hilsenhof biotic indexes (HBI's) were under 5.0 with a significant number of taxa, with higher percentages of EPT and other sensitive species. Sensitive species may indicate lower silt levels, higher flows, cooler temperatures, and/or a more complex substrate.

Moderately impaired sites had good taxa richness, percentages of sensitive species and tolerant species were similar. A more tolerant benthic community may indicate significant organic enrichment, excessive sedimentation, higher water temperatures, and/or low flows.

Sites R03 and R11 suggest a moderate to severe impairment with a significantly higher number of very tolerant species and HBI's close to 7.0. The most severely impaired site is R05 with an HBI of 8.0, a taxa richness of 7, and 99 percent of the organisms being tolerant to very tolerant (See Table 35). A highly tolerant benthic community may indicate organic pollution and/or excessive sedimentation.

Table 35. Macroinvertebrate Final Index Values and Suggested Impairment for the BSR Sites

Site	Macroinvertebrates	Suggested Impairment
R01	68	Moderate
R02	69	Minimal to Moderate
R03	56	Moderate to Severe
R04	61	Moderate
R05	18	Severe
R06	70	Minimal
R07	62	Moderate
R08	79	Minimal to Moderate
R09	70	Moderate
R10	81	Minimal
R11	72	Moderate to Severe
R12	86	Minimal
R13	83	Minimal to Moderate

Source Linkage and Conclusion

Fecal Coliform Bacteria Reductions and Sources

Based on modeling and loading calculations, fecal coliform bacteria (Table 36) and TSS (Table 37) would need the following reductions at each site:

Table 36. Percent Fecal Coliform Bacteria Reduction and Possible Sources for the BSR Sites

Site	Numeric Criteria	Fecal % Reduction *(Flow)	Event vs Base Flow	Possible Sources
R01	2000	0	NA	NA
R02	2000	0	NA	NA
R03	2000	0	NA	NA
R04	2000	0	NA	NA
R05	2000	0	NA	NA
R06	2000	61 (D)	Both	failing septic systems, instream livestock, inadequate manure application, and feedlot runoff
R07	2000	0	NA	NA
R08	400	29 (H)	Event	absent/poor riparian areas, system overflows
R09	400	99 (H)	Event	absent/poor riparian areas, system overflows
R10	400	91 (H), 94 (M)	Event	absent/poor riparian areas, system overflows, failing septic systems, instream livestock, inadequate manure application, and feedlot runoff, urban runoff
R11	400	76 (H), 52 (L)	Event	absent/poor riparian areas, system overflows, failing septic systems, instream livestock, and feedlot runoff, urban runoff
R12	400	96 (H), 39(D)	Event	absent/poor riparian areas, system overflows, failing septic systems, instream livestock, inadequate manure application, and feedlot runoff
R13	400	95 (H), 69 (D)	Event	absent/poor riparian areas, system overflows, failing septic systems, instream livestock, inadequate manure application, and feedlot runoff

* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%) MR=Mid-Range Flows (40-60%)
D=Dry Conditions (60-90%) L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and base flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, feedlot runoff, and urban runoff. According to the feedlot inventory, there are 69 feedlots within this drainage area with a ranking ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the low flows. There are 12 known NPDES permits within the drainage area. Of these 12, seven are identified as point sources that discharged during the sampling period. (See Table 31). Their contributions were calculated to be insignificant. Reductions should focus on non-point sources.

TSS Reductions and Sources

Table 37. Percent TSS Reduction and Possible Sources for the BSR Sites

Site	Numeric Criteria	TSS % Reduction	Possible Sources
R01	158	10	TBD
R02	158	0	NA
R03	158	17	Cropland erosion, streambank erosion, construction erosion
R04	158	2	Cropland erosion, streambank erosion, construction erosion
R05	158	0	NA
R06	158	0	NA
R07	158	0	NA
R08	158	0	NA
R09	158	11	Cropland erosion , streambank erosion, construction erosion,
R10	158	47	Urban runoff, streambank erosion, construction erosion
R11	158	22	Urban runoff, streambank erosion, construction erosion
R12	158	30	Urban runoff, streambank erosion, construction erosion cropland erosion
R13	158	72	Urban runoff, streambank erosion, construction erosion, cropland erosion

TSS reduction is needed at R01, R03, R04, R09, R10, R11, R12 and R13. The 11 percent (R09), and the 72 percent (R13) reductions, correlates with the SDM findings of high erosion potential cropland with, six percent (1,305 acres) at R09, and 11 percent (2,608 acres) at R13. TSS reduction at R09 and R13 would need to come from urban runoff, construction site activities, streambank erosion and high erosion potential (HEP) cropland in the area. The reduction at R01 could not be correlated with the SDM due to unavailability of data out of the study area. The 17 percent (R03) reduction does not correlate with the one percent of HEP (1277 acres) at R03 (includes LMU I, O, C, and J). Therefore the contribution of TSS from cropland is minimal for these areas. The SDM shows less than 1 percent HEP for R04, so the two percent reduction in TSS, is probably not due to HEP cropland. The SDM shows zero percent HEP for R10, so the 47 percent reduction in TSS at R10, could be attributed to urban runoff, construction erosion, and instream bed and bank erosion. R11 and R12 need a 22 percent and a 30 percent reduction in TSS, respectively. The SDM shows five percent for R11 and 10 percent for R12 from HEP, respectively.

However, there is little cropland within this area, indicating that reductions would need to come from urban runoff, construction site activities and/or streambank erosion. There are eight point sources identified as contributing to TSS during the monitoring period, however their total contribution in less than one percent (See Table 30).

Point Sources

Analysis of the NPDES facilities for TSS (Table 30) shows that the City of White is contributing approximately two percent. This municipality is not the major causes of TSS problems in the area, but is showing to be a contributor to the overall effects. Analysis of the NPDES facilities for fecal coliform bacteria shows very insignificant amounts of contribution from these facilities based on monthly geomeans. It was noted however, that the City of Hartford had some very high daily maximums. It may be beneficial to consider reducing the daily maximum allowed, due to the fact that even if these geomeans show there is no affect for the month, does not mean there is not some type of affect on beneficial use (7) or (8) on a daily basis.

The four percent contribution to TSS for the City of Sioux Falls area represents the well-developed residential, commercial, and industrial areas; however this percentage could increase with increased construction erosion activities if proper stormwater management is not implemented.

Non-Point Sources (NPS)

Non-point source pollution of TSS and fecal coliform bacteria is much more difficult to pinpoint. However, it is a known fact that NPS pollution is caused by rainfall or snowmelt runoff. Sediment sources of pollution include agricultural runoff, construction site runoff, urban runoff, and eroding stream banks/beds. Fecal coliform bacteria NPS pollution can include instream livestock watering, urban and agricultural runoff, and faulty septic systems.

NPS pollution is the leading cause of water quality problems in rivers. The National Water Quality Inventory (2000), found the top three leading sources of water quality impairment are agriculture, hydrologic modification, and habitat modification. For this study, the main sources of NPS pollution point to agricultural practices and stream/habitat changes.

The SDM and AGNPS models, as well as the load duration intervals with hydrologic zones, were used to analyze samples of TSS and fecal coliform bacteria to produce overall reductions needed. This section analyzes each major subwatershed and concludes with a set of priority management areas for TSS and fecal coliform bacteria reductions.

North Deer/Six Mile Creek Subwatershed

This map (Figure 68) shows the area and location designated as the North Deer/Six Mile Creek Subwatershed and the potential for erosion.

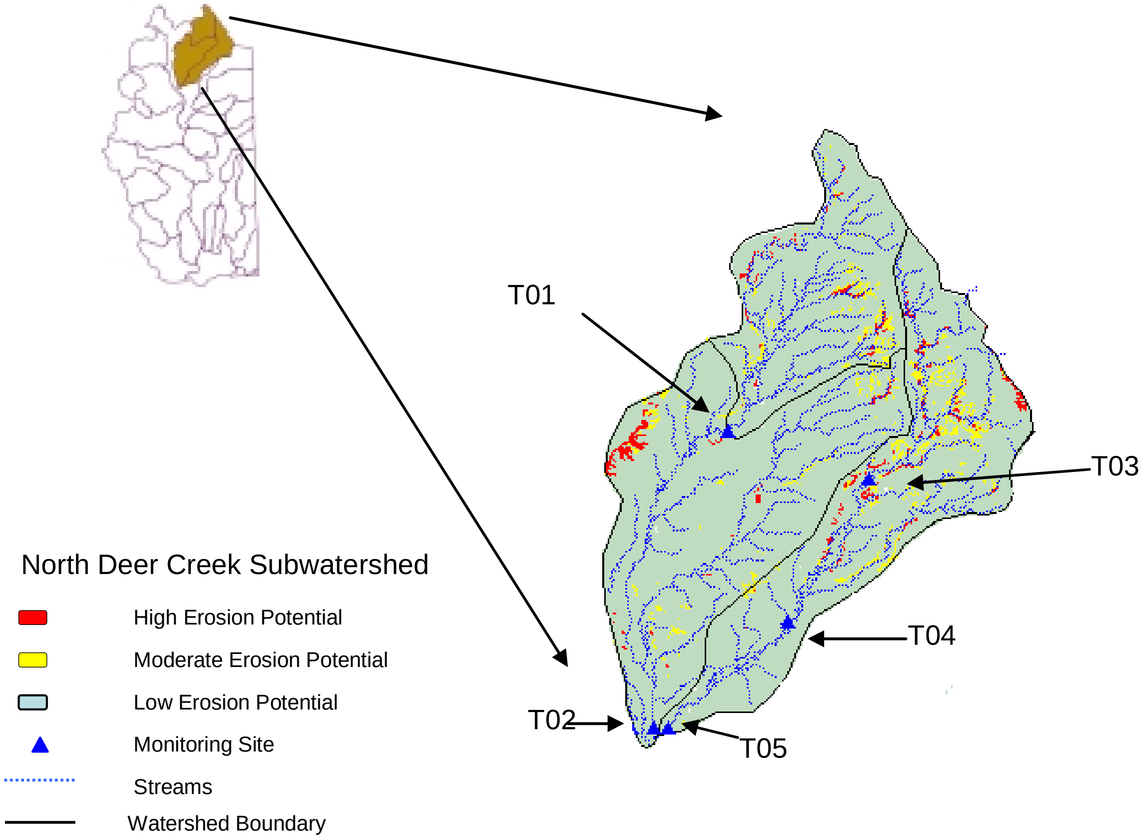


Figure 68. North Deer/Six Mile Creek Subwatershed Location Map

Land Use Summary

Land use in the watershed is predominantly agricultural (Figure 69). Approximately 61 percent of the area is cropland, such as corn and soybeans, and 36 percent is grassland and pastureland. There are a total of 69 animal feeding operations in this subwatershed, with approximately 87 percent being cattle (See Figure 70). There are three NPDES permitted facilities (See Table 30 and 31).

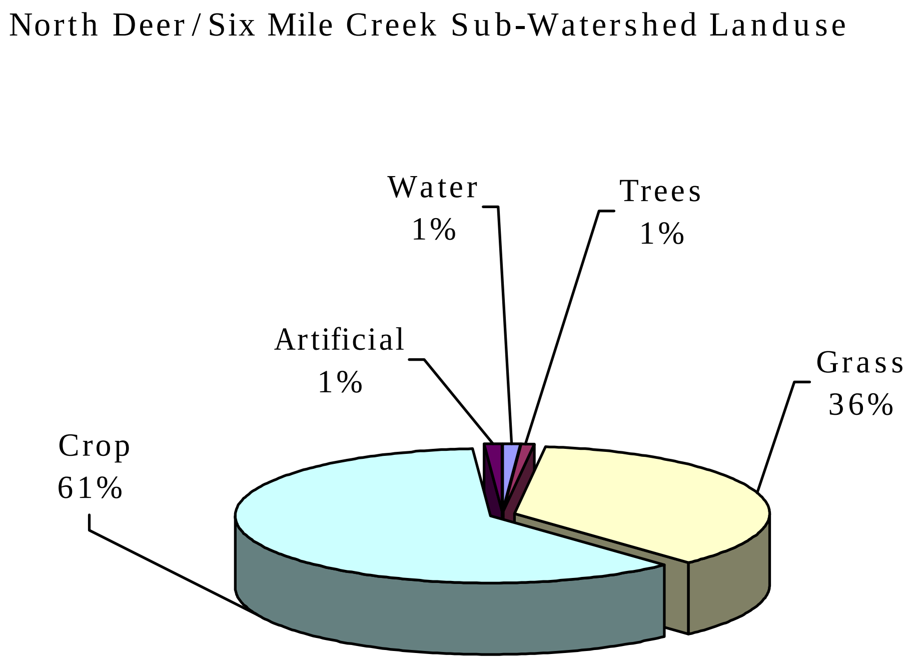


Figure 69. North Deer/Six Mile Creek Subwatershed Landuse

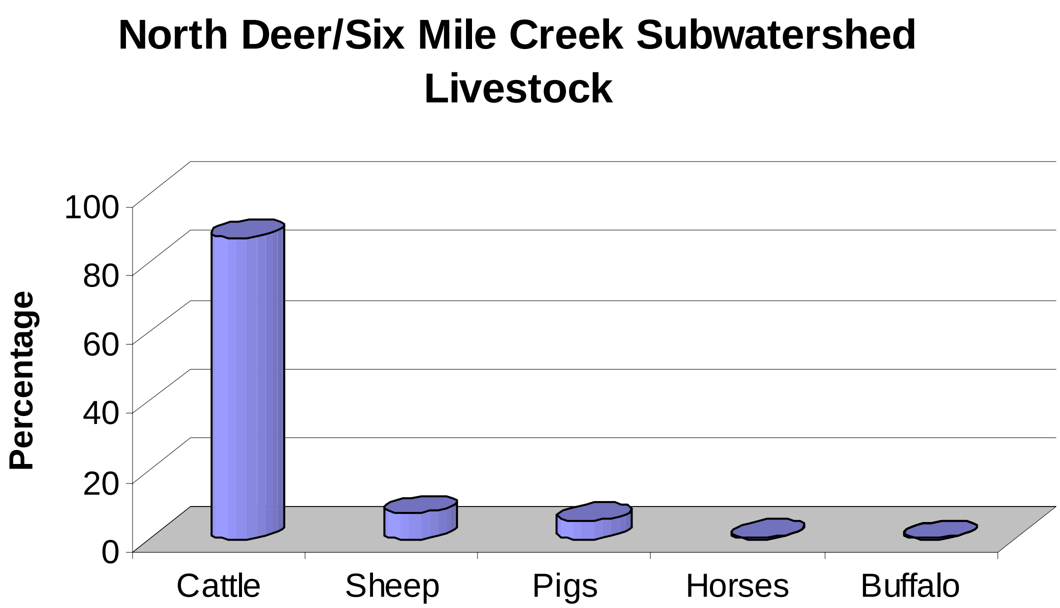


Figure 70. North Deer /Six Mile Creek Subwatershed Livestock

Water Quality Summary

The North Deer/Six Mile Creek subwatershed (T01-T05), located in the Northern Glaciated Plains, is meeting the criteria for all water quality and field parameters except for fecal coliform bacteria. Beneficial uses listed for the sites in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

The subwatershed is meeting water quality criteria for beneficial use (6) and (8) for DO ($\geq$ 5 mg/L), unionized ammonia (0.0875), pH (6.0-9.5), water temperature (32.2 ^{o} C), and TSS (263 mg/L). It is not meeting water quality criteria for fecal coliform bacteria (2000 cfu/100mL) at sites T02, T04, and T05. (See Figure 71).

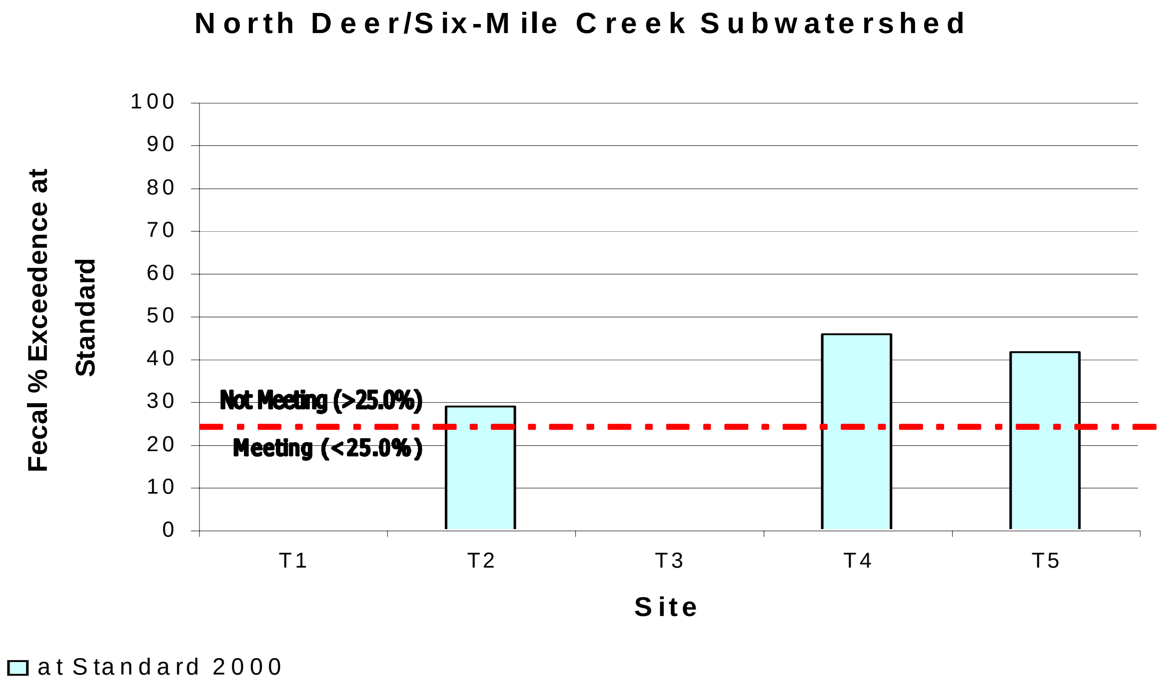


Figure 71. Fecal Coliform Bacteria Percent Exceedence at Standard 2000cfu/100mL for the North Deer/Six Mile Creek Subwatershed

Based on average daily discharge and seasonal grab sample data, graphs were constructed showing the monitored loadings and the allowable target loads at the 2000 cfu/100mL water quality standard, within each of the five hydrologic conditions (See Figure 72). Scatterplots of the fecal coliform bacteria grab samples are shown in Figure 73.

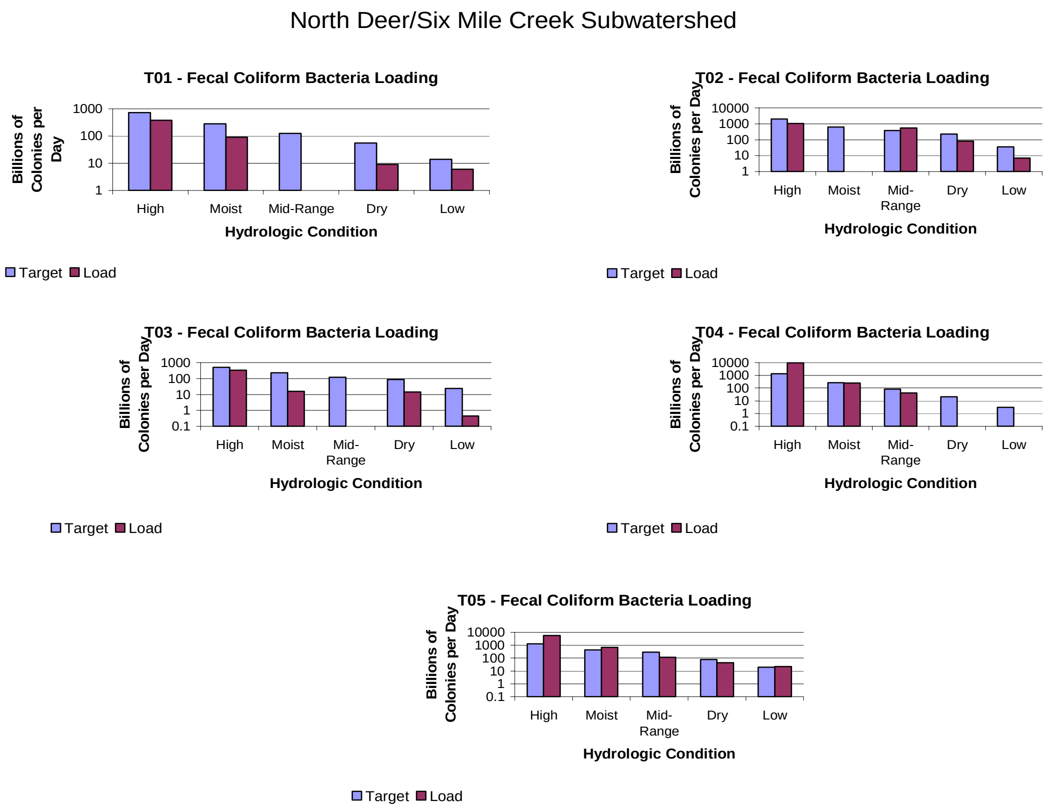


Figure 72. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the North Deer/Six Mile Creek Subwatershed

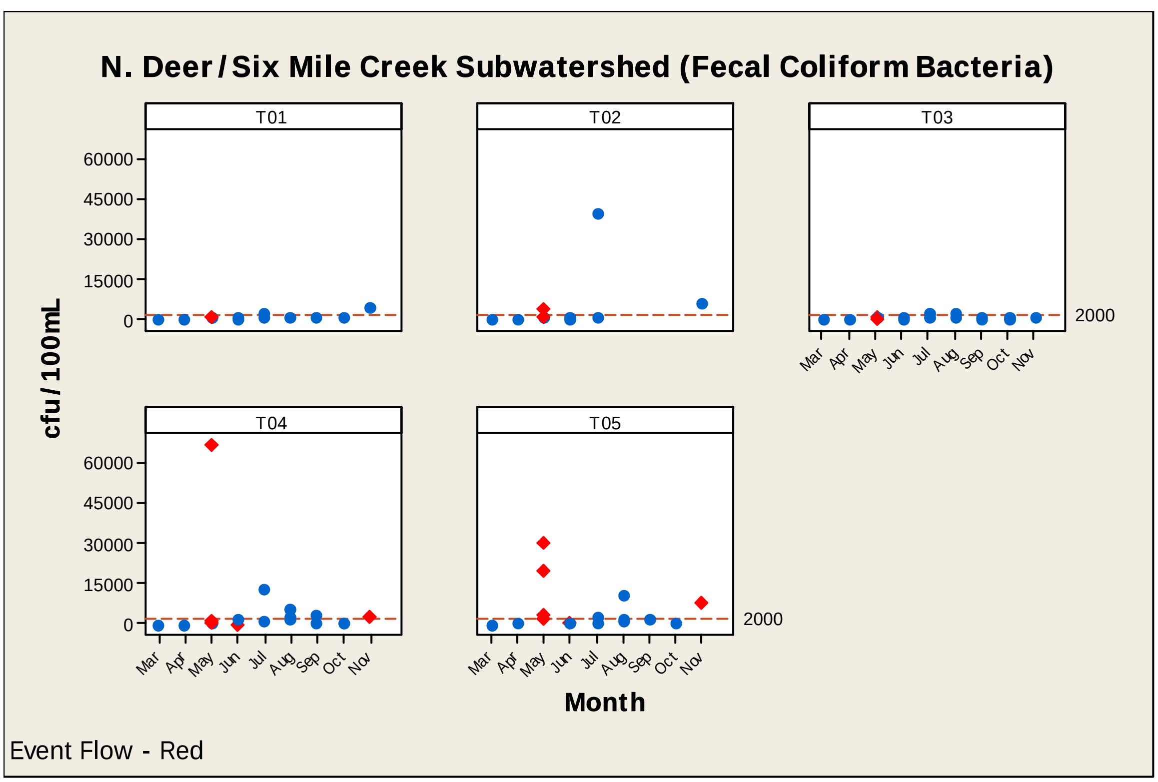


Figure 73. Scatterplot of Fecal Coliform Bacteria Grab Samples for North Deer/Six Mile

Creek Subwatershed

Figure 74 shows this subwatershed is meeting the water quality criteria for TSS. Based on FLUX model results, Figure 75 shows the estimated TSS loadings of T01-T05 as compared to the allowable load of 263 mg/L. The TSS grab samples collected during the study are shown in Figure 76.

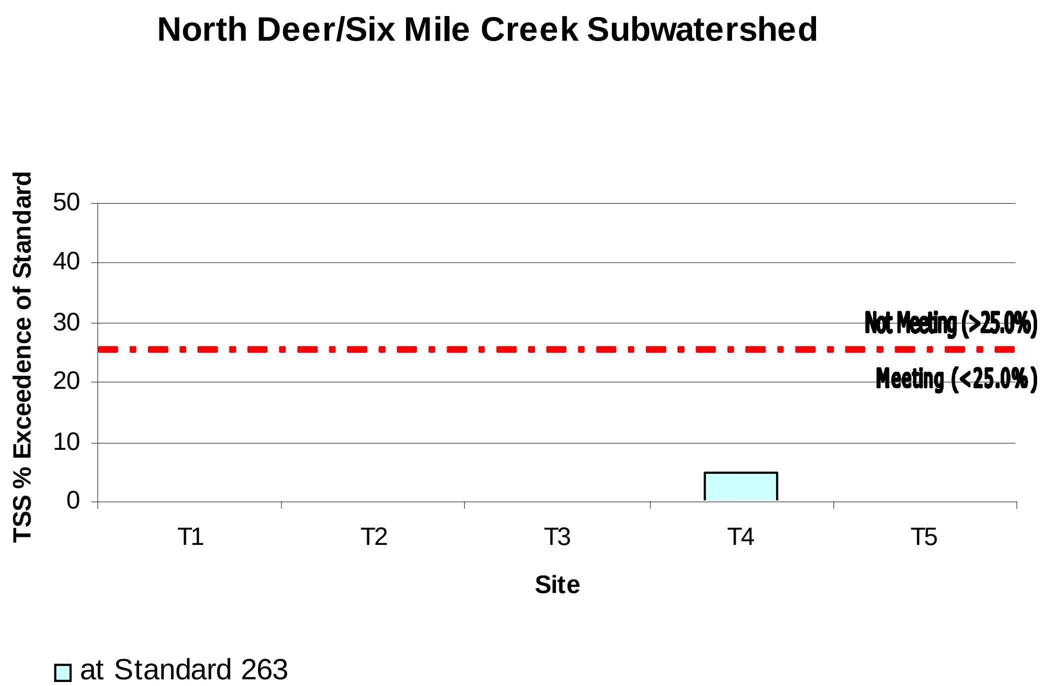


Figure 74. TSS Percent Exceedence at Standard 263 mg/L for the North Deer/Six Mile Creek Subwatershed

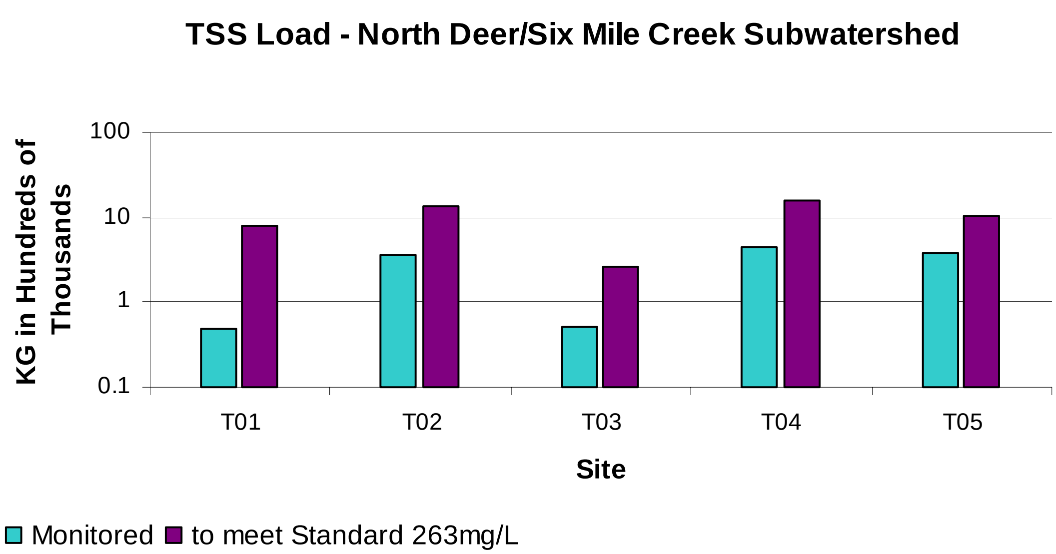


Figure 75. TSS in kg Monitored vs the Standard for the North Deer/Six Mile Creek Subwatershed

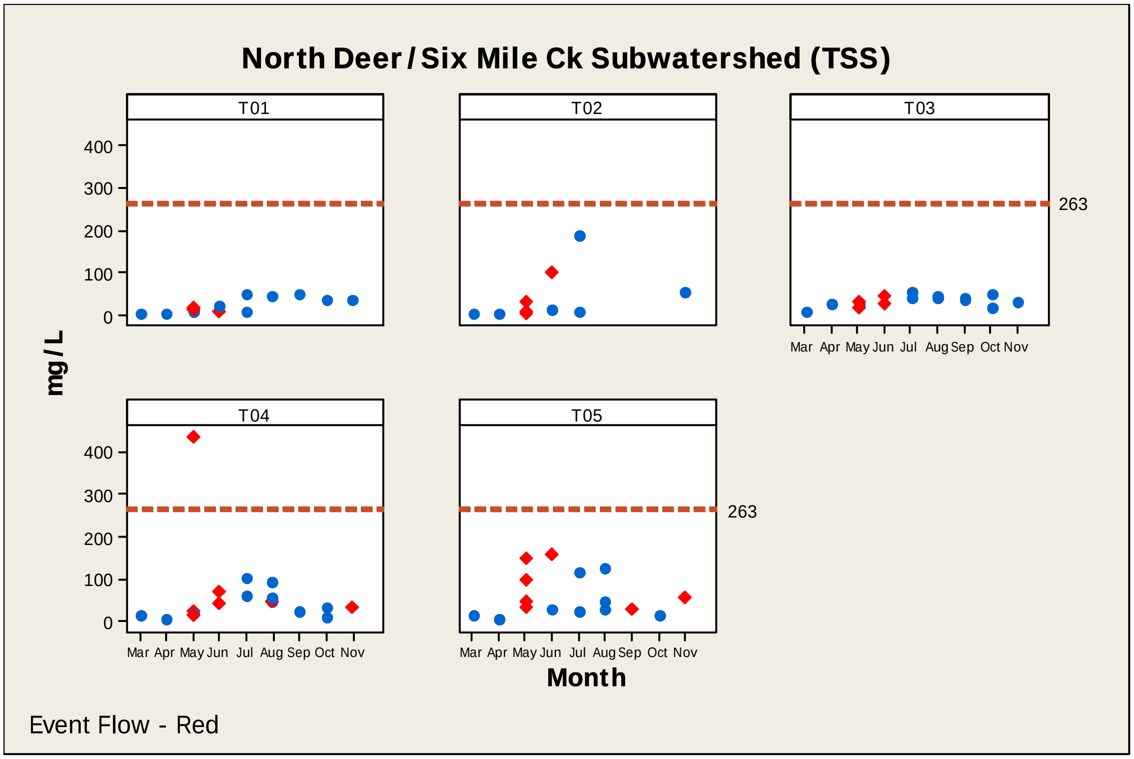


Figure 76. Scatterplot of TSS Grab Samples for the North Deer/Six Mile Creek Subwatershed

Additionally, linear regressions were completed for each monitoring location to find the relationship between TSS and NTU (See Figure 77). R^2 ranged from 0.4561 to .9674.

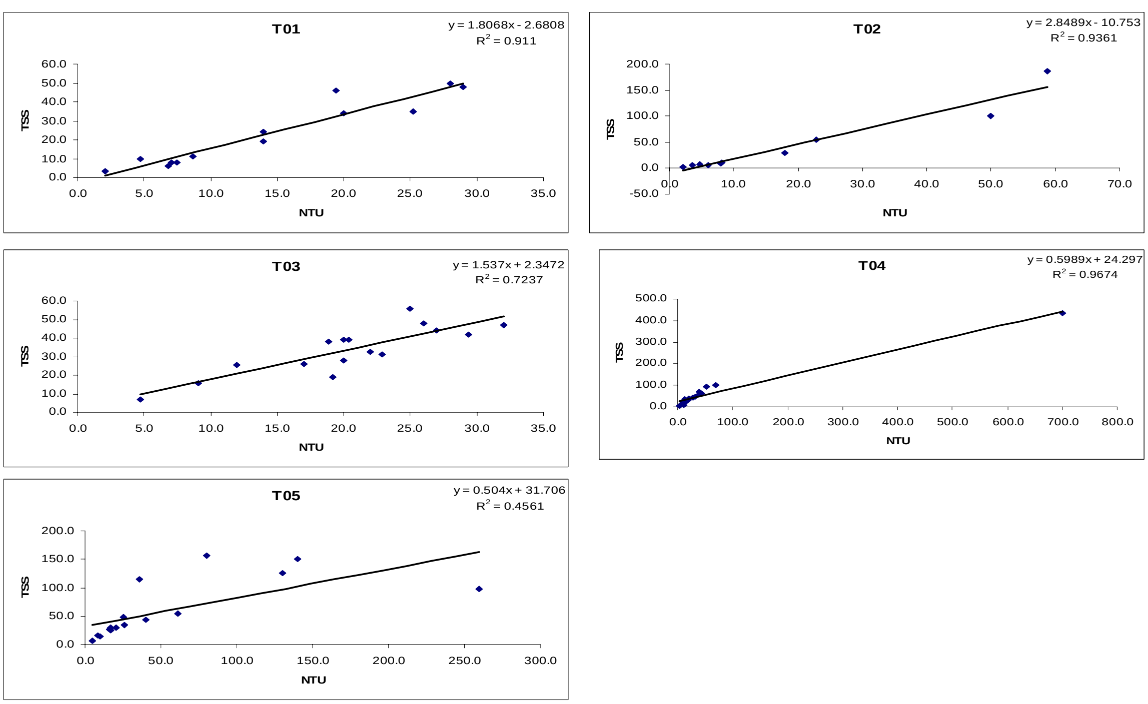


Figure 77. Comparison of TSS and Turbidity for the North Deer/Six Mile Creek Subwatershed

The North Deer/Six Mile Creek subwatershed meets the water quality criteria for beneficial uses (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation.

The following table (Table 38) summarizes the ranges of fecal coliform bacteria (cfu/100mL), ranges of TSS (mg/L), and the percent exceedences. It also shows the summer mean of total PO4 (mg/L).

Table 38. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 for the North Deer/Six Mile Creek Subwatershed

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
T01	30-1900	0	3-50	0	0.18
T02	70-39000	29	2-186	0	0.21
T03	10-1800	0	7-56	0	0.16
T04	70-67000	46	4-436	5	0.25
T05	230-30000	42	6-157	0	0.29

The summer mean concentrations for total phosphorus for each site R01-R05 fall within, or are very close to the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Biological and Physical Habitat Summary

Fish, habitat, and macroinvertebrates were collected for all the sites in the North Deer Creek Subwatershed, with the exception of T01, T02, and T03 where no macroinvertebrates were collected due to dry streams. Score sheets for each of these sites can be found in Appendix I for fish, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for these sites are listed in Table 39 and ranged from minimal to moderate.

Sites T01 and T02 rated similarly. Site T02 scored higher with fishes, while T01 had a higher habitat score. Site T02, which is downstream from T01, lacked habitat complexity and rated poorly on measure of incision. T03 ranked very well in habitat and fair to good in fishes.

All sites, except T04, had very low numbers of benthic insectivore fish species. These fish decline when benthic habitat is subjected to sedimentation and reduced oxygen. Sites T02 and T05 had low numbers of sensitive fish species. The sensitive/intolerant species are usually the first to be affected by major sources of degradation such as siltation, low DO, reduced flow, and/or chemical contamination. T04 had a much higher abundance of red shiners, bigmouth shiners, and sand shiners. Topeka Shiners were found at sites T02 (1) and T03 (311). Topeka Shiners are associated with lower water temperatures and isolated instream pools influenced by groundwater (Kerns 1999).

Site T05 scored lower than T04 in physical habitat due to lack of overhanging vegetation and poor bed composition. Site T04 had a significantly lower macroinvertebrate score than T05 due to an absence of Trichopteran species. The lack of Trichopertans results in very low values for the EPT and an HBI score of 8.48, indicating serious biota problems.

Table 39. Final Index Values for Bugs, Fish, and Habitat for the North Deer/Six Mile Creek Subwatershed

Site	Macroinverts	Fish	Habitat	Suggested Impairment
T01	NA*	51	68	Minimal
T02	NA*	65	52	Minimal to Moderate
T03	NA*	64	80	Minimal
T04	53	71	70	Minimal to Moderate
T05	66	64	63	Minimal to Moderate

* dry stream

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria (Table 40) and TSS (Table 41) would need the following reductions at each site:

Table 40. Percent Fecal Coliform Bacteria Reduction and Possible Sources for the North Deer/Six Mile Creek Subwatershed

Site	Numeric Standard	Fecal % Reduction *(Flow)	Event vs Base Flow	Possible Sources
T01	2000	0	NA	NA
T02	2000	40 (MR)	Both	poor riparian areas, instream livestock, inadequate manure application, feedlot runoff, and urban runoff
T03	2000	0	NA	NA
T04	2000	87 (H)	Both	poor riparian areas and failing septic systems
T05	2000	79 (H), 39 (M), 21 (L)	Both	poor riparian areas, failing septic systems, instream livestock, inadequate manure application, feedlot runoff, and urban runoff

* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%) MR=Mid-Range Flows (40-60%)
D=Dry Conditions (60-90%) L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and at low flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, feedlot runoff, and urban runoff from the City of Brookings. According to the feedlot inventory, 35 of the 69 feedlots within this subwatershed rank ≥50 on a 0 to 100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the baseflow high fecal counts. The City of White and the City of Brookings were identified as point sources that discharged during the sampling period. Their contributions were calculated to be insignificant. Reductions should focus on non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas section).

Table 41. Percent TSS Reduction and Possible Sources for the North Deer/Six Mile Creek Subwatershed

Site	Numeric Standard	TSS % Reduction	Possible Sources
T01	263	0	NA
T02	263	0	NA
T03	263	0	NA
T04	263	0	NA
T05	263	0	NA

TSS reductions are not needed for any of the sites in this subwatershed. The cities of White and Brookings are the only identified point source contributor to TSS. The City of White contributes approximately two percent of the TSS load at T04 and the City of Brookings contributes approximately three percent of the TSS load at T05 during the sampling period in the North Deer Creek/Six Mile Creek subwatershed (See Table 30).

Medary/Deer Creek Subwatershed

This map (Figure 78) shows the area and location designated as the Medary/Deer Creek Subwatershed and the potential for erosion.

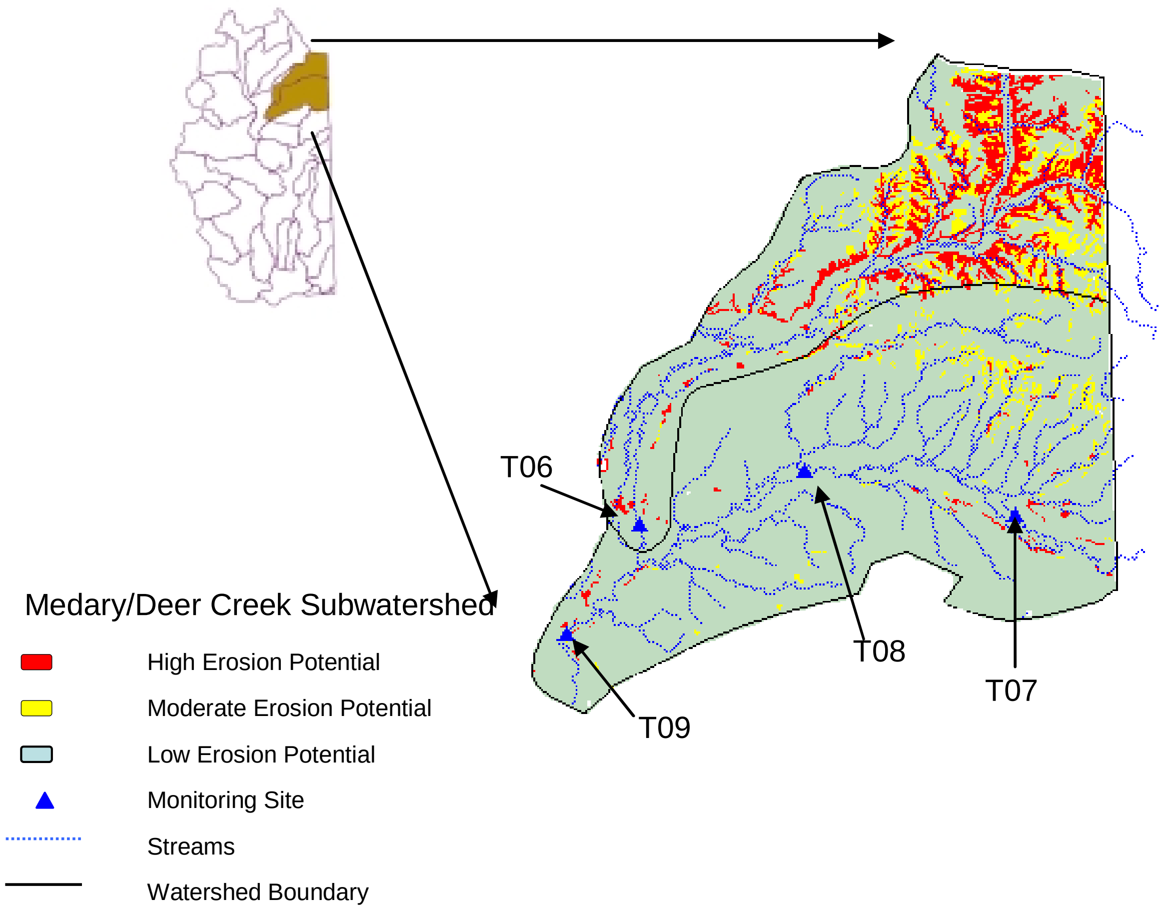


Figure 78. Medary/Deer Creek Subwatershed Location Map

Land Use Summary

Land use in the watershed is predominantly agricultural (Figure 79). Approximately 57 percent of the area is cropland, such as corn and soybeans, and 41 percent is grassland and pastureland. There are a total of 76 animal feeding operations in this subwatershed, with 65 percent cattle (See Figure 80). There is one identified NPDES permitted facilities (See Table 30 and 31).

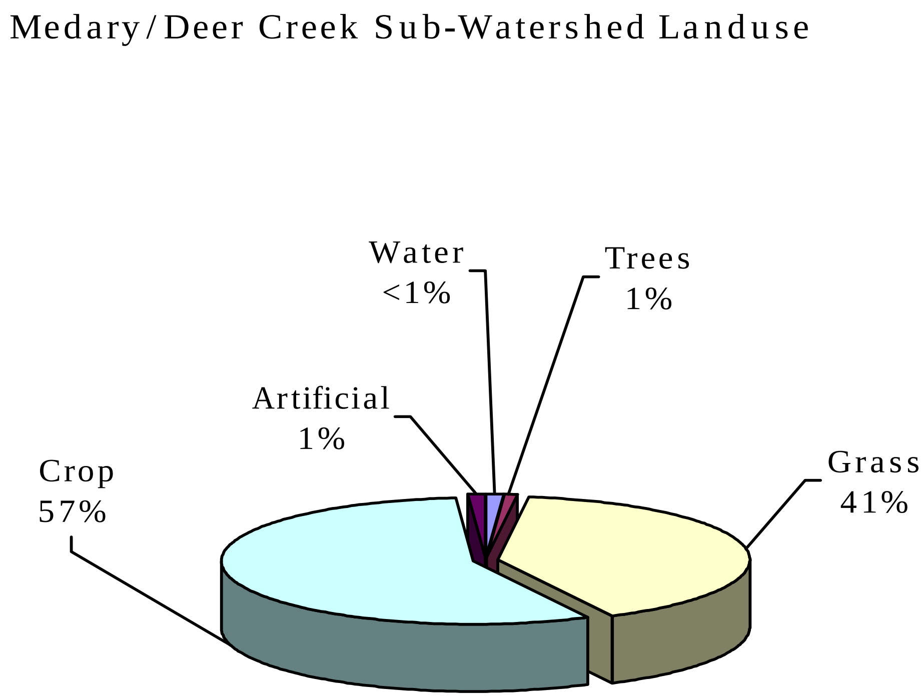


Figure 79. Medary/Deer Creek Subwatershed Landuse

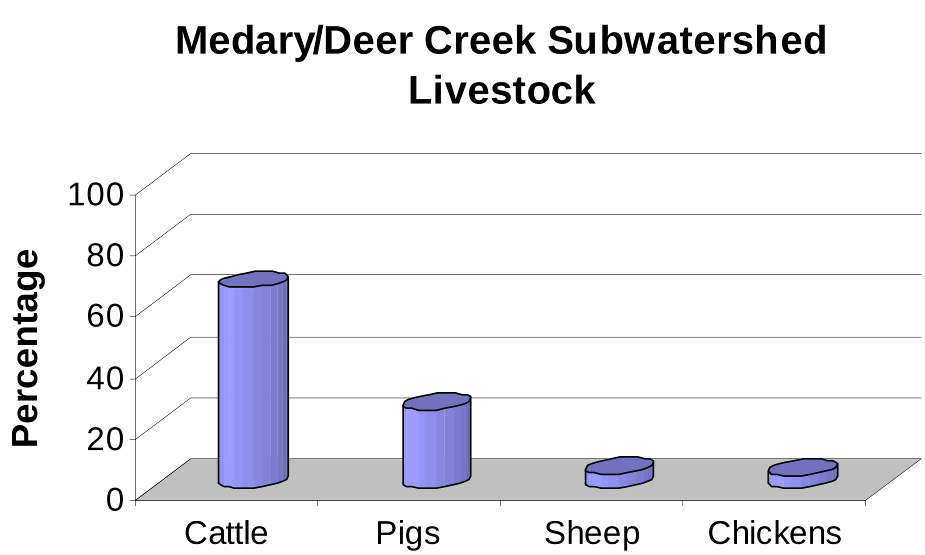


Figure 80. Medary/Deer Creek Subwatershed Livestock

Water Quality Summary

The Medary/Deer Creek subwatershed sites (T06-T09), located in the Northern Glaciated Plains, is meeting the criteria for all water quality and field parameters. Beneficial uses listed for the sites in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Beneficial use (6) and (8) are only assigned to sites T06 and T09. These sites are meeting water quality criteria for DO (≥ 5 mg/L), unionized ammonia (0.0875), pH (6.0-9.5), water temperature (32.2 ^{o} C), TSS (263 mg/L), and fecal coliform bacteria (2000 cfu/100mL).

Figure 81 shows this subwatershed is meeting the water quality criteria for TSS. Based on FLUX model results, Figure 82 shows the estimated TSS loadings of T06-T09 as compared to the allowable load of 263 mg/L. Grab samples collected during the study are shown in Figure 83.

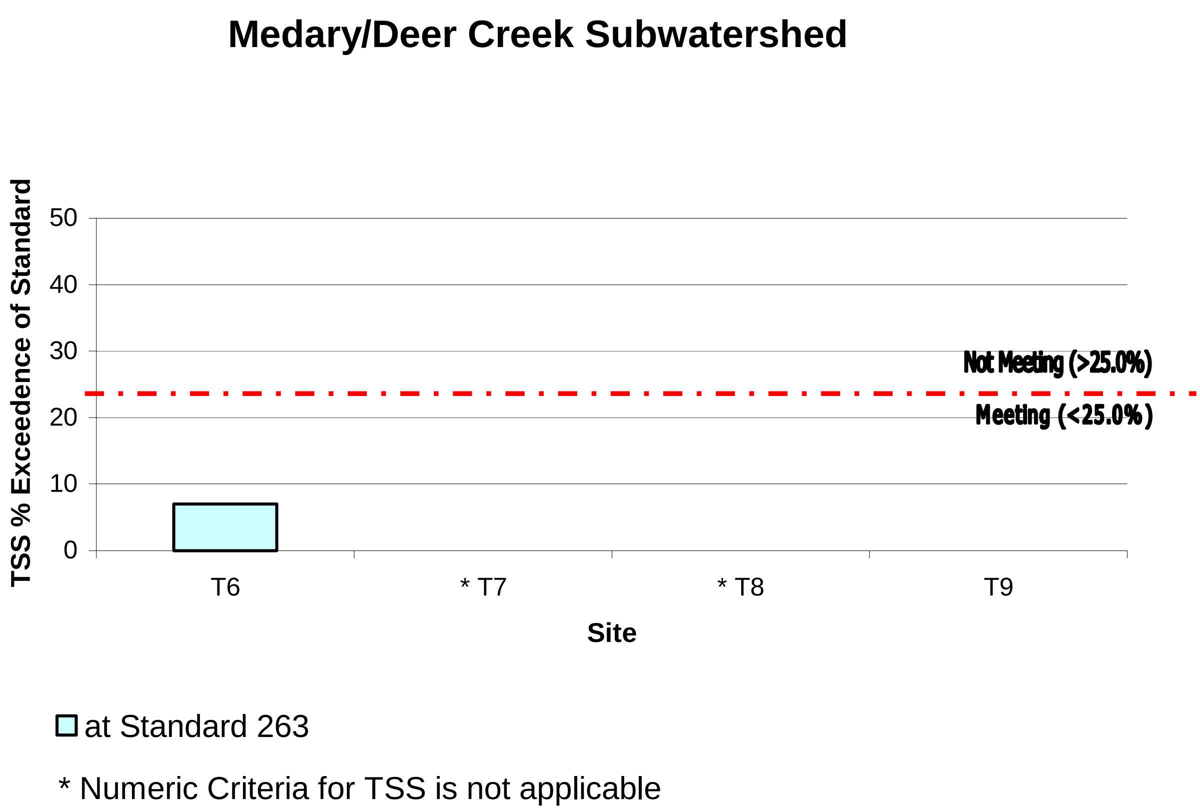


Figure 81. TSS Percent Exceedence at Standard 263mg/L for the Medary/Deer Creek Subwatershed

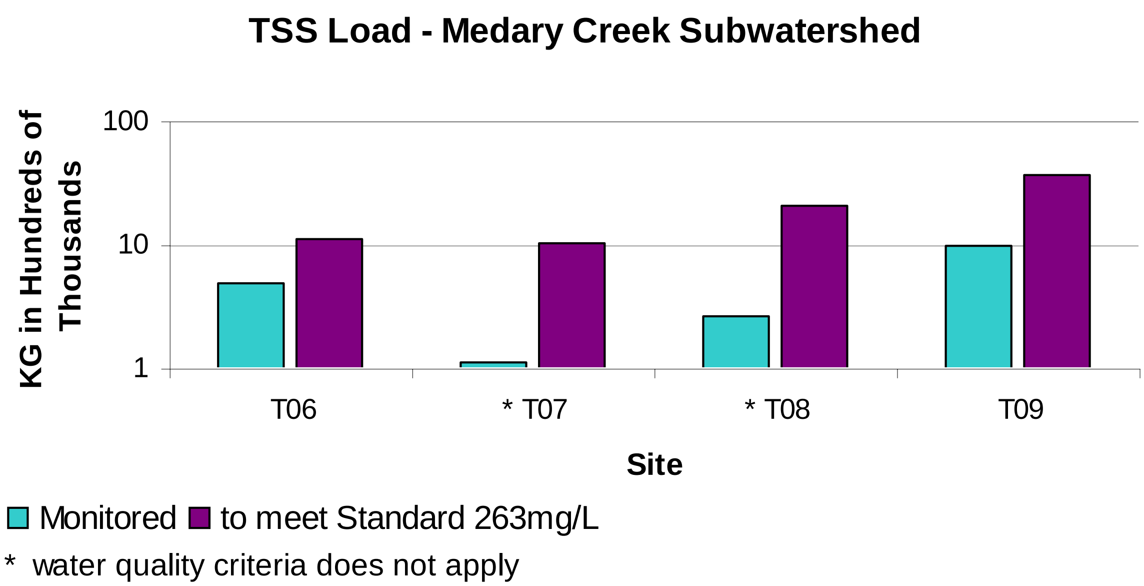


Figure 82. TSS in kg Monitored vs the Standard for the Medary/Deer Creek Subwatershed

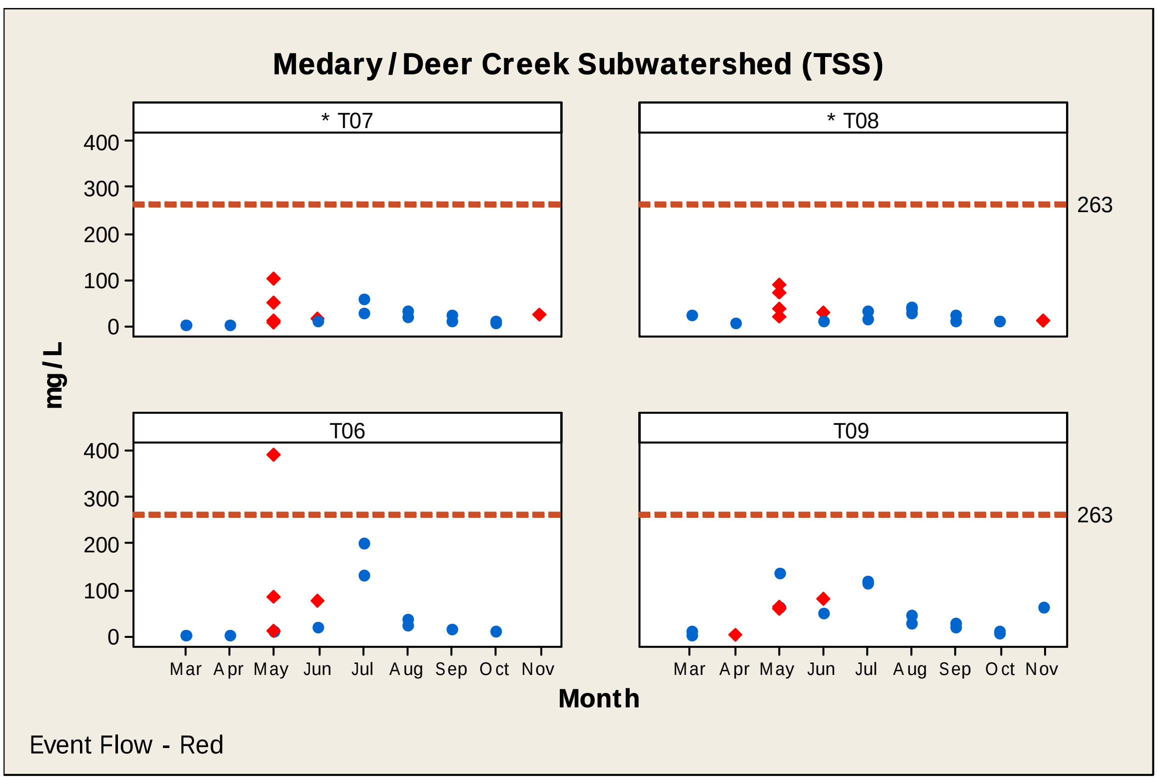


Figure 83. Scatterplot of TSS Grab Samples for Medary/Deer Creek Subwatershed

Additionally, linear regressions were completed for each monitoring location to find the relationship between TSS and NTU (See Figure 84). R^2 ranged from 0.7657 at Site T08 to 0.9642 at Site T06.

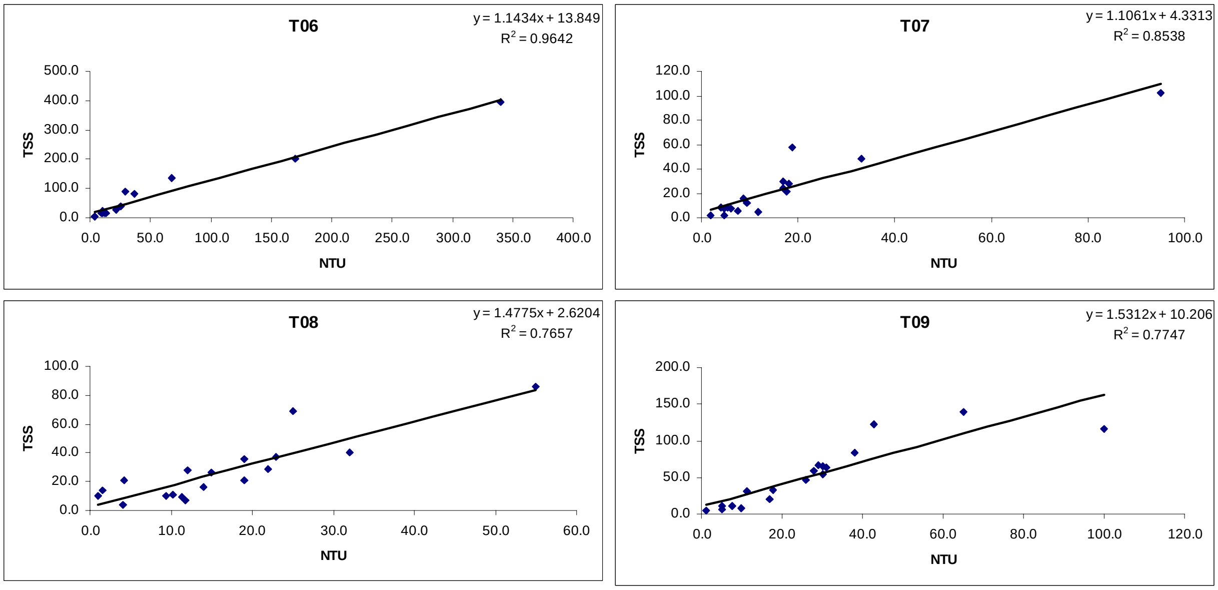


Figure 84. Comparison of TSS and Turbidity for the Medary/Deer Creek Subwatershed

Figure 85 shows this subwatershed is meeting the water quality criteria for fecal coliform bacteria. Based on average daily discharge and seasonal grab sample data, graphs were constructed for fecal coliform bacteria showing the monitored loadings and the allowable target loads at the 2000 cfu/100mL water quality standard, within each of the five hydrologic conditions (See Figure 86). Grab samples collected during the study are shown in Figure 87.

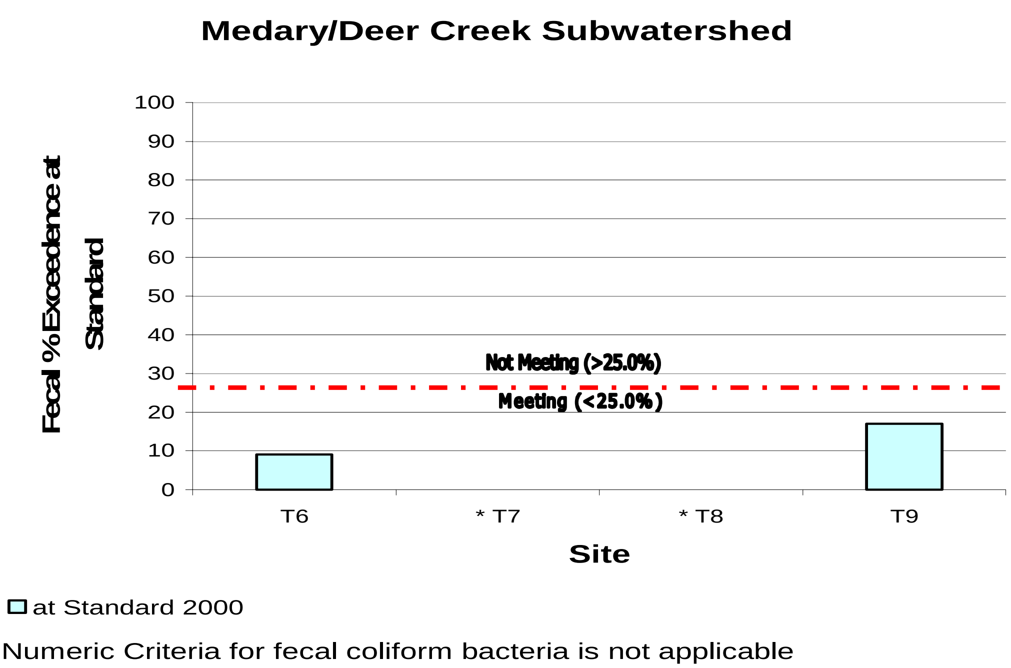


Figure 85. Fecal Coliform Bacteria Percent Exceedence at Standard 2000 cfu/100mL for the Medary/Deer Creek Subwatershed

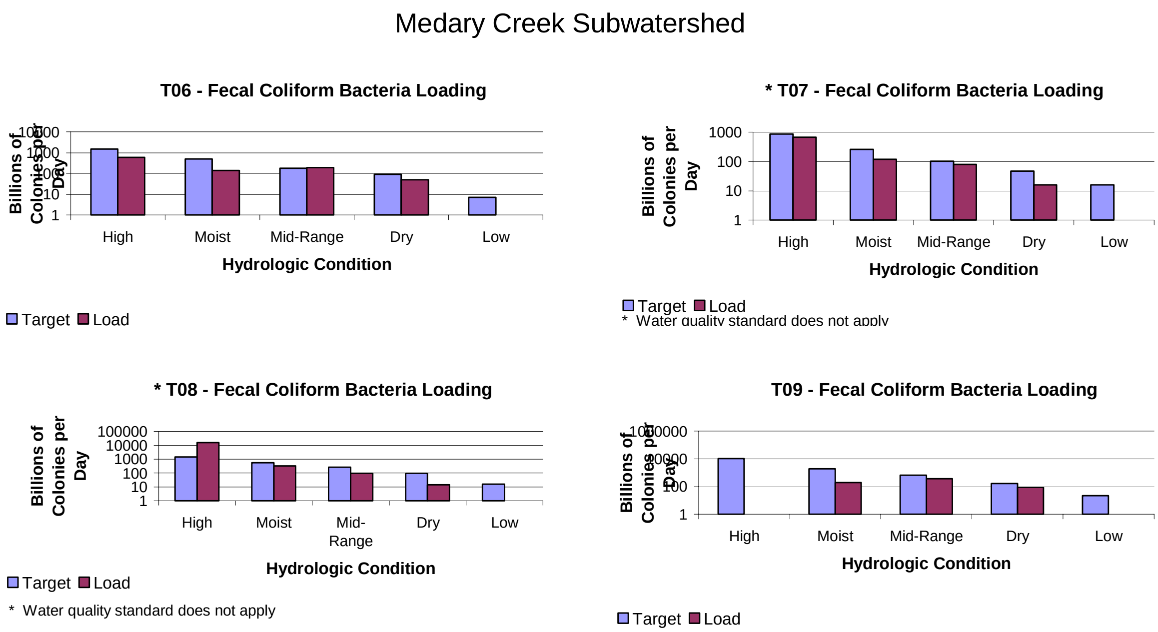


Figure 86. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Medary/Deer Creek Subwatershed

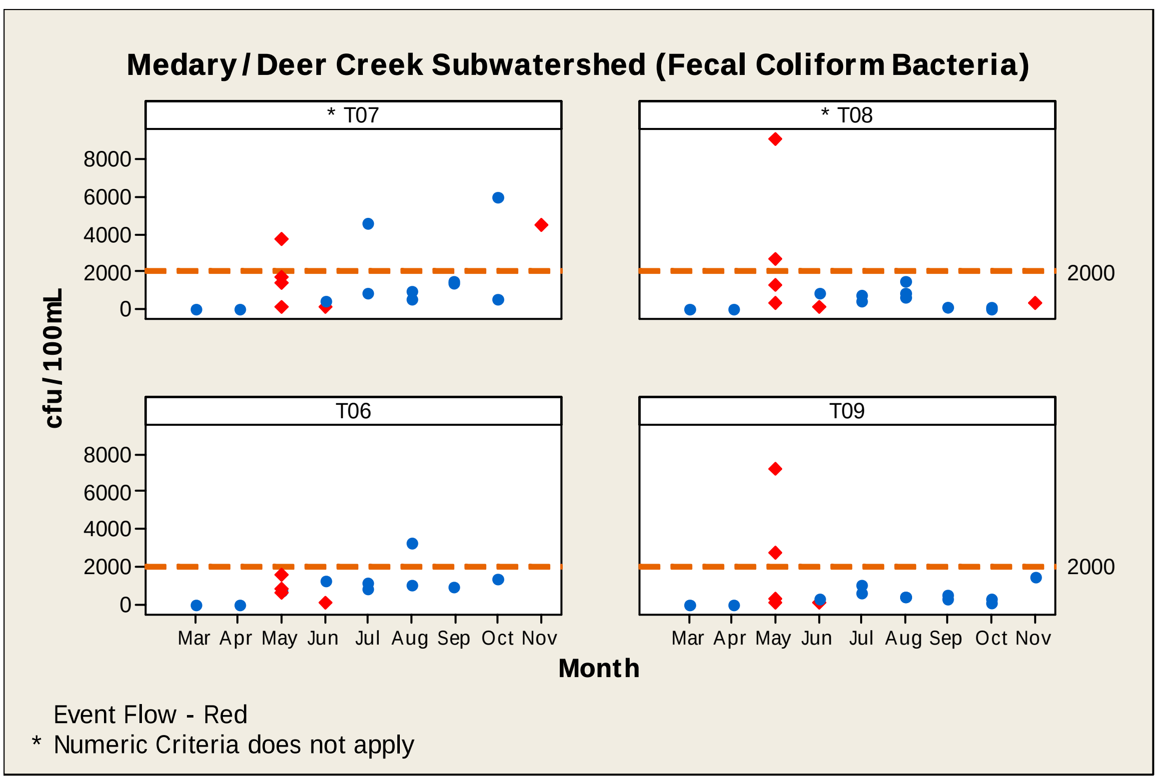


Figure 87. Scatterplot of Fecal Coliform Bacteria Grab Samples for Medary/Deer Creek Subwatershed

The Medary/Deer Creek subwatershed meets the water quality criteria for beneficial uses (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation.

The following table (Table 42) summarizes the ranges of fecal coliform bacteria (cfu/100mL), ranges of TSS (mg/L), and the percent exceedences. It also shows the summer mean of total PO4 (mg/L). The summer mean concentrations for total phosphorus at each site fall within the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Table 42. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 for the Medary/Deer Creek Subwatershed

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
T06	60-3300	9	4-394	7	0.21
T07	60-4600	--	2-102	--	0.13
T08	80-9000	--	4-86	--	0.16
T09	90-72000	17	5-140	0	0.17

-- water quality criteria not applicable

Biological and Physical Habitat Summary

Fish, habitat, and macroinvertebrates were collected for all the sites in the Medary Creek Subwatershed. Score sheets for each of these sites can be found in Appendix I for fishes, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for these sites is listed in Table 43. Overall, all four sites rated very similarly.

Site T09 ranked the highest and had an astounding fish IBI of 90. Two Topeka Shiners were found at site T09 and T08, along with abundant Red Shiners, Sand Shiners, Bigmouth Shiners, and Johnny Darters. Sensitive species richness was high at these two sites.

Habitat at all these sites rated poor to fair. Common characteristics included lack of overhanging vegetation and moderate to heavy animal vegetation use.

Macroinvertebrates at all sites rated fair. HBI scores ranged from 5.6 to 7.2, indicating poor water quality due to disturbance. At all sites there were a higher percentage of tolerant organisms than percentage of EPT. More tolerant benthic communities may indicate significant organic enrichment, excessive sedimentation, higher water temperatures, and/or low flows. Overall, all four sites suggest minimal impairment.

Table 43. Final Index Values for Bugs, Fish, and Habitat for the Medary/Deer Creek Subwatershed

Site	Macroinverts	Fish	Habitat	Suggested Impairment
T06	70	69	58	Minimal
T07	58	77	59	Minimal
T08	62	75	46	Minimal
T09	66	90	52	Minimal

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria (Table 44) and TSS (Table 45) would need the following reductions at each site:

Table 44. Percent Fecal Coliform Bacteria Reduction and Possible Sources for the Medary/Deer Creek Subwatershed

Site	Numeric Standard	Fecal % Reduction *(Flow)	Event vs Base Flow	Possible Sources
T06	2000	14 (MR)	Both	instream livestock, inadequate manure application, and feedlot runoff, poor riparian areas
T07	--	--	NA	NA
T08	--	--	NA	NA
T09	2000	0	NA	NA

-- numeric standard not applicable
* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%) MR=Mid-Range Flows (40-60%)
D=Dry Conditions (60-90%) L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, there are 21 feedlots within this subwatershed with a ranking ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the low flows. The City of Aurora is the only identified point source, however they did not discharge during the sampling period. Reductions should focus on non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Area sections).

Table 45. Percent TSS Reduction and Possible Sources for the Medary/ Deer Creek Subwatershed

Site	Numeric Standard	TSS% Reduction	Possible Sources
T06	263	0	NA
T07	--	--	NA
T08	--	--	NA
T09	263	0	NA

-- numeric standard not applicable

TSS reduction is not needed for any of the sites in this subwatershed. The City of Aurora is the only identified point source identified, however they did not discharge during the sampling period (See Table 30).

Lake Campbell Outlet Subwatershed

This map (Figure 88) shows the area and location designated as the Lake Campbell Outlet Subwatershed and the potential for erosion.

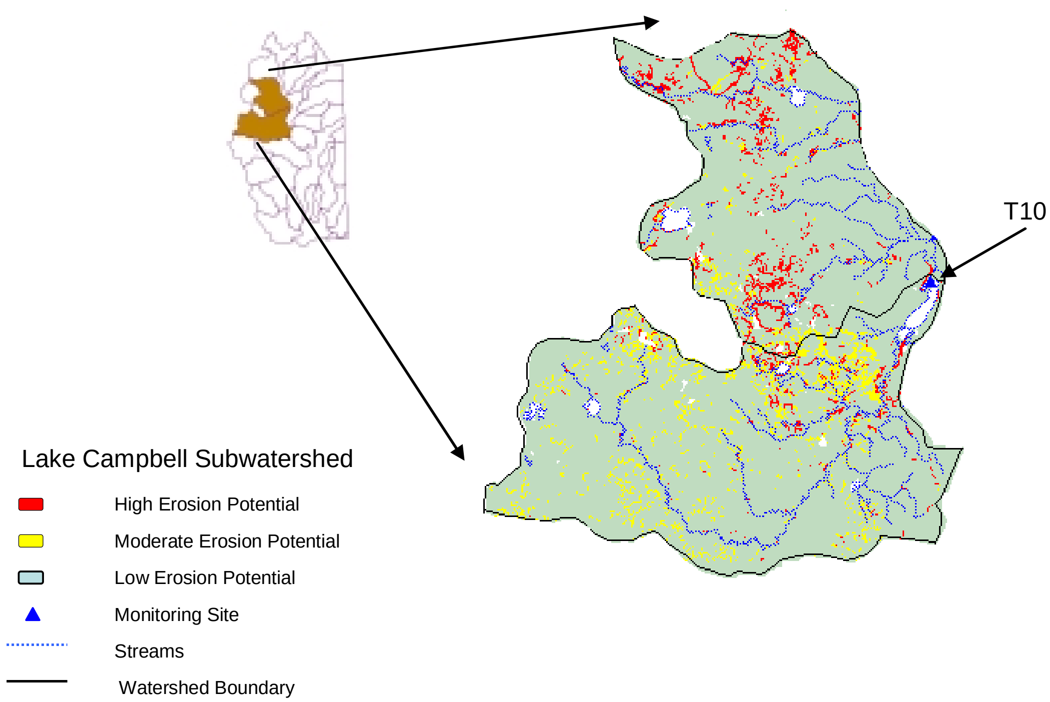


Figure 88. Lake Campbell Outlet Subwatershed Location Map

Land Use Summary

Land use in the watershed is predominantly agricultural (Figure 89). Approximately 63 percent of the area is cropland, such as corn and soybeans, and 30 percent is grassland and pastureland.

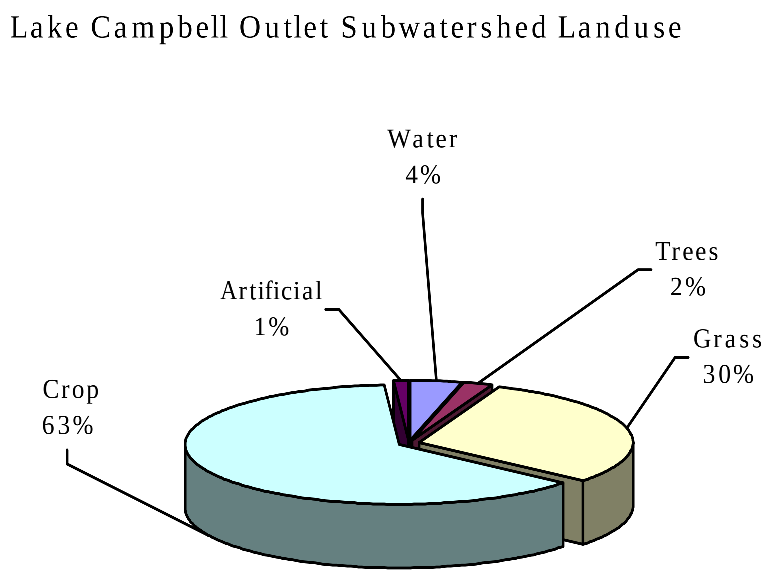


Figure 89. Lake Campbell Outlet Subwatershed Landuse

Water Quality Summary

The Lake Campbell Outlet subwatershed site (T10), located within the Northern Glaciated Plains, is meeting the water quality criteria for its beneficial uses (9) Fish and Wildlife Propagation, Recreation and Stock Watering and (10) Irrigation (refer to Table 6 for each site's beneficial use).

Fecal coliform bacteria ranged from 10-7200 cfu/100mL, DO ranged from 2.9-20.0, and TSS ranged from 7-206 mg/L. This subwatershed is not assigned water quality criteria for DO, fecal coliform bacteria or TSS. However, the following Figure 90 is based on average daily discharge and seasonal grab sample data and shows the monitored loading of fecal coliform bacteria as compared to a targeted load of 2000 cfu/100mL. Grab samples collected during the study are shown in Figure 91.

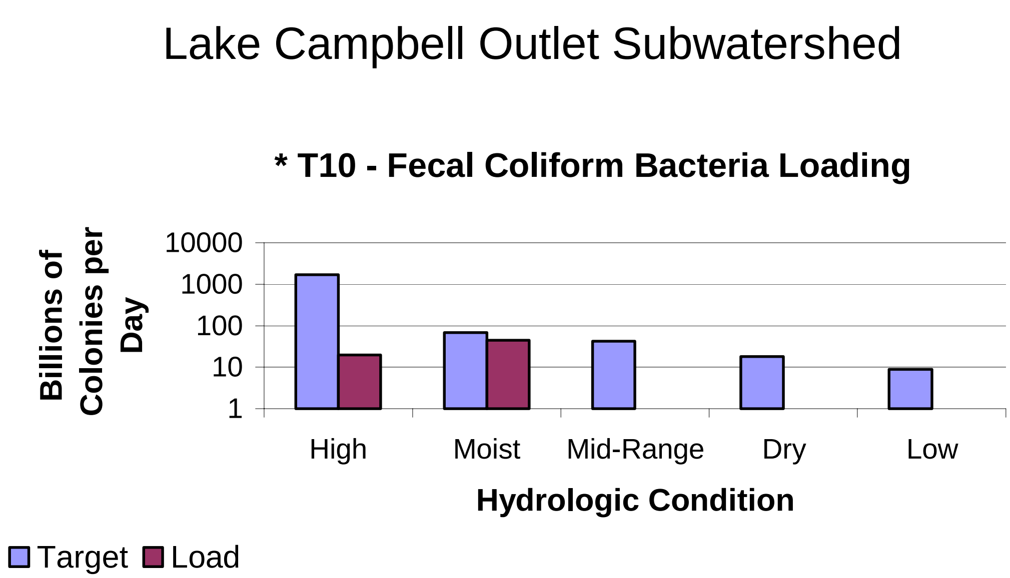


Figure 90. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Lake Campbell Outlet Subwatershed

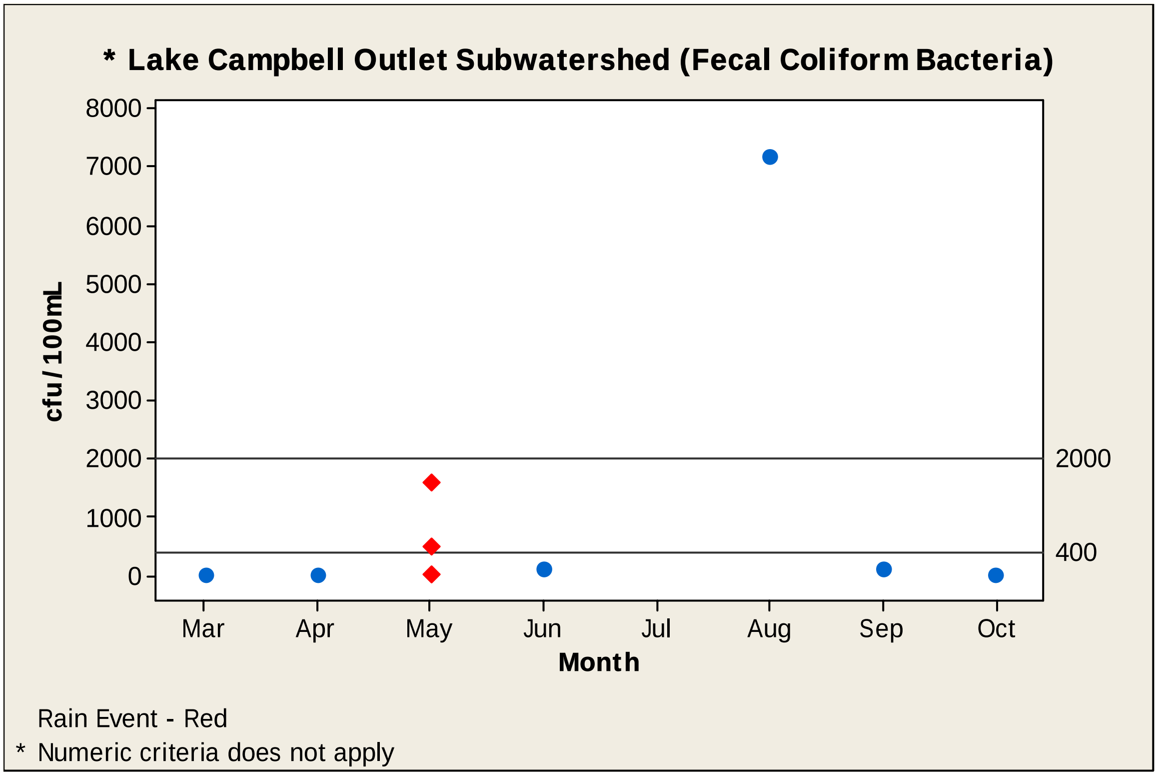


Figure 91. Scatterplot of Fecal Coliform Bacteria Grab Samples for Lake Campbell Outlet Subwatershed

Based on FLUX model results, Figure 92 shows the estimated TSS loadings for T10 as compared to a standard of 263 mg/L. Grab samples collected during the study are shown in Figure 93.

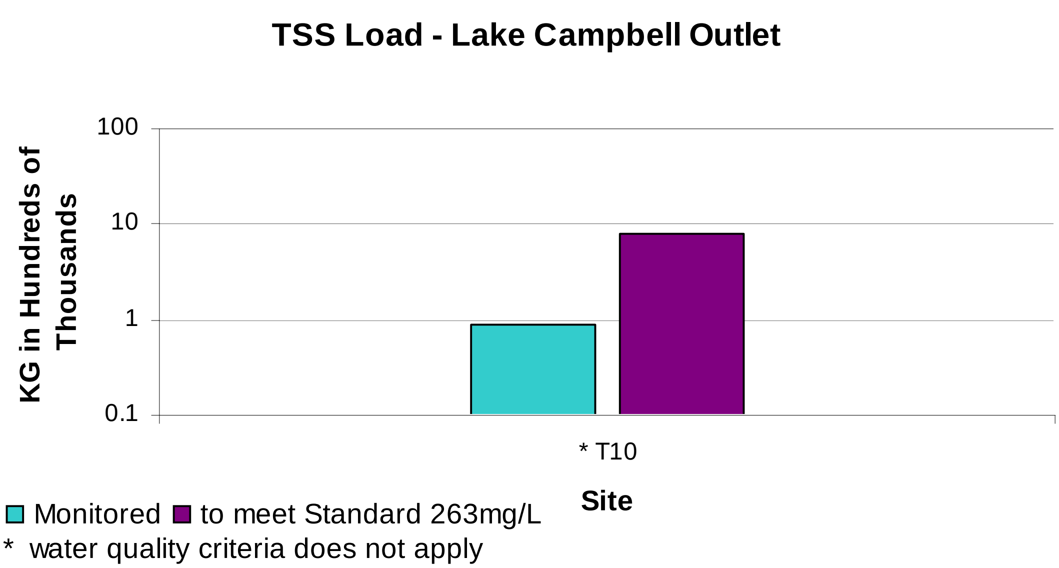


Figure 92. TSS in kg Monitored in Comparison to a Standard of 263 mg/L in the Lake Campbell Outlet Subwatershed

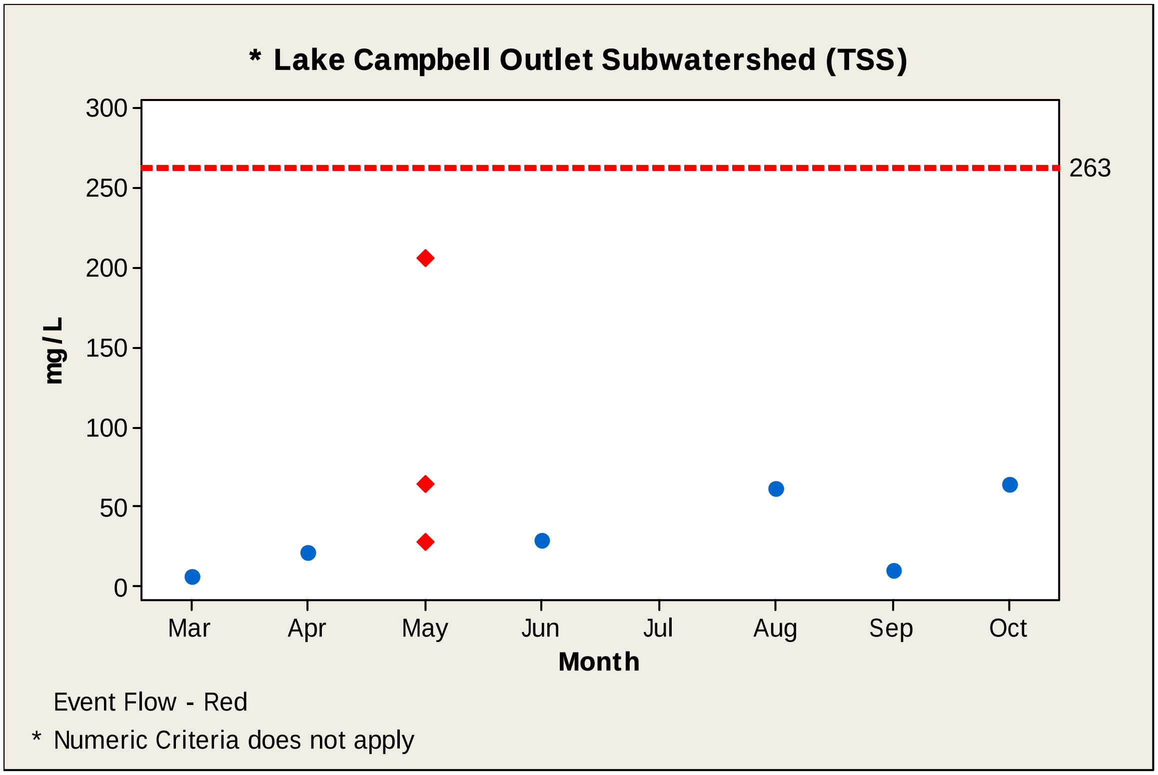


Figure 93. Scatterplot of TSS Grab Samples for Lake Campbell Outlet Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, R^2 = 0.9687 (See Figure 94).

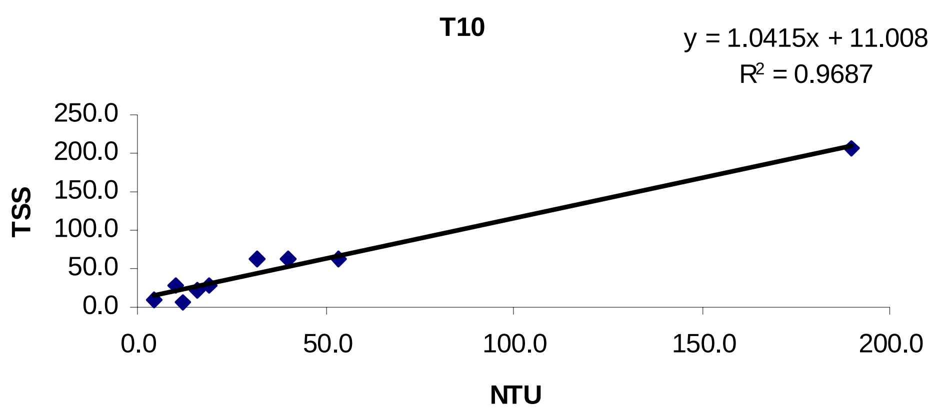


Figure 94. Comparison of TSS and Turbidity for the Lake Campbell Outlet Subwatershed

The total phosphorus summer mean was 0.488 mg/L, as compared to the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988), which is almost double of what it should be. Based on the site location, this is more representative of the in-lake concentrations and excessive algae production in Lake Campbell. This could also be the primary cause of the low DO readings.

Biological Data Summary

Fish, habitat, and macroinvertebrates were collected in the Lake Campbell Subwatershed. Score sheets for this site can be found in Appendix I for fishes, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for this site is moderate to severe.

The fish IBI score of 33 was low due to only two species being found. Tolerant omnivores dominated with the two species being the Common Carp and the Iowa Darter. Carp are an introduced species and usually thrive in lakes or sluggish streams especially rich in organic matter. Iowa Darters are common to lake habitat and are sometimes found in streams connected to lakes. Due to this being a lake outlet, abundant typical small stream species did not occur.

The macroinvertebrate IBI score of 45 was poor, with an HBI of 7.2. The percentage of EPT was almost non-existent and there was very low taxa richness - an overall poor benthic community.

The physical habitat scored very low in velocity, bed composition and overhanging vegetation. This site is a poor site to consider as a typical small stream.

Source Linkage and Conclusion

As stated earlier, this subwatershed is meeting its assigned water quality criteria. There are no standards set for fecal coliform bacteria or TSS. In addition, a diagnostic/feasibility study was previously completed for this subwatershed entitled “Diagnostic/Feasibility Study Report Lake Campbell/Battle Creek Watershed Brookings, Lake and Moody Counties, South Dakota dated January 1993”. See this report (Madison and Wax 1993) for further detailed data, discussion and recommendations.

Spring Creek Subwatershed

Figure 95 shows the area designated as Spring Creek Subwatershed and the potential for erosion.

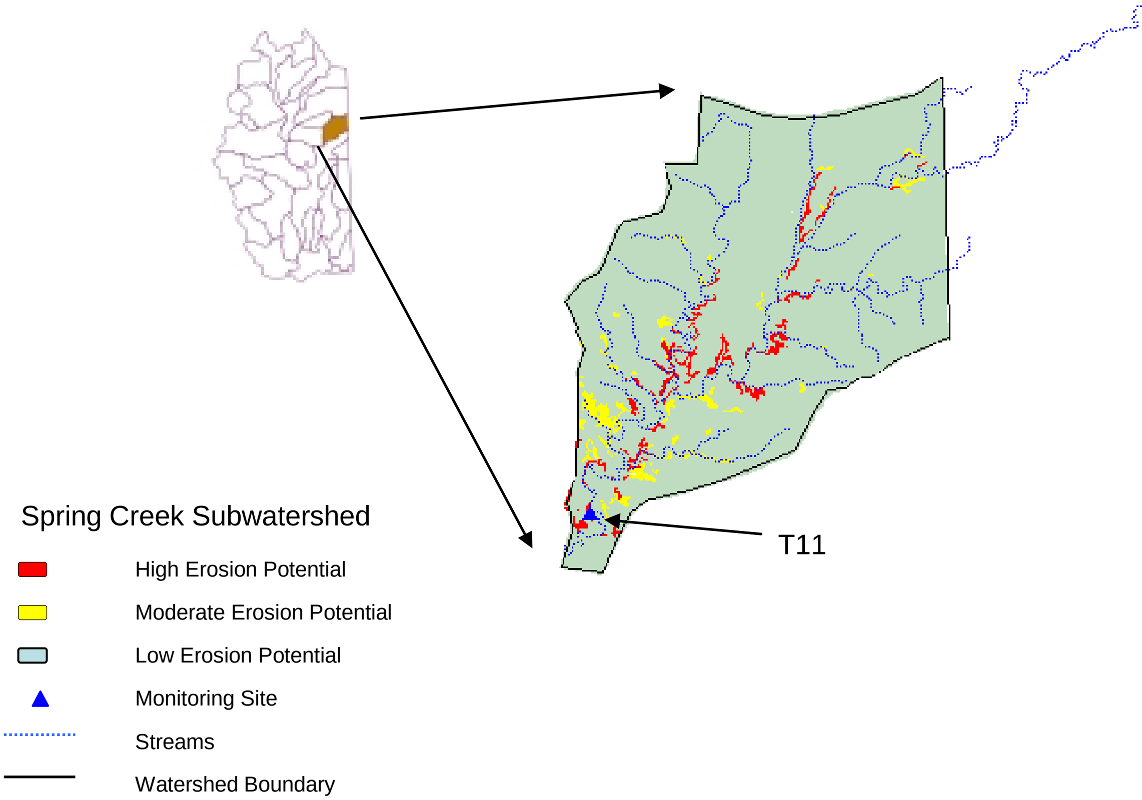


Figure 95. Spring Creek Subwatershed Location Map

Land Use Summary

Land use in the Spring Creek watershed (T11) is predominantly agricultural (Figure 96). Approximately 62 percent of the area is cropland, such as corn and soybeans, and 35 percent is grassland and pastureland. There were a total number of 28 feedlots according to the feedlot inventory, with 90 percents of the livestock being cattle (See Figure 97). The town of Elkton is the only municipality within the watershed.

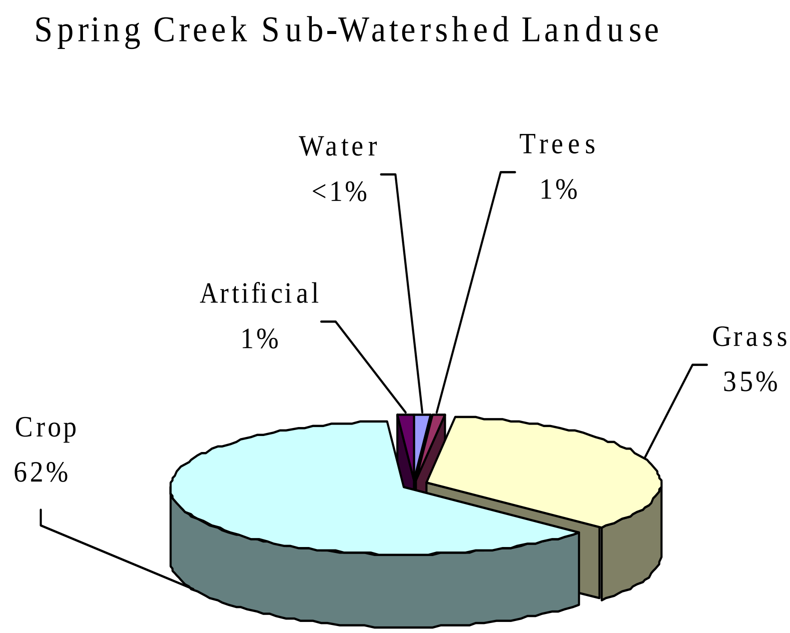


Figure 96. Spring Creek Subwatershed Landuse

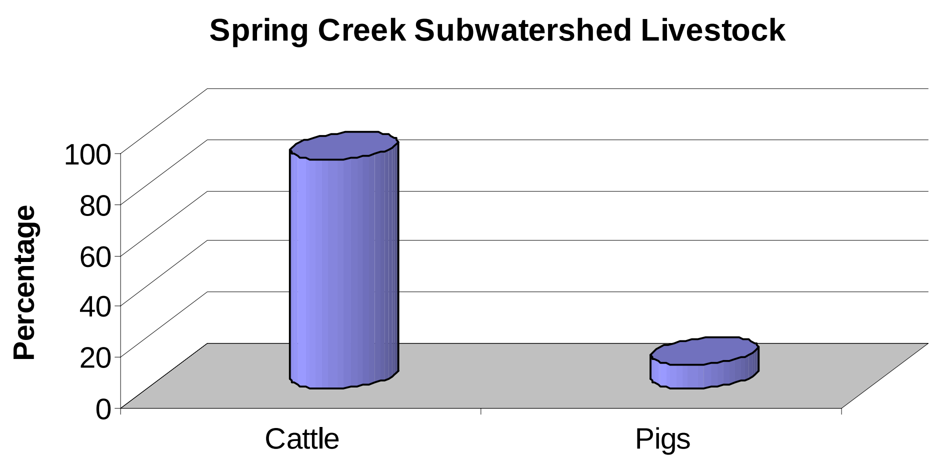


Figure 97. Spring Creek Subwatershed Livestock

Water Quality Summary

The Spring Creek subwatershed site (T11), located within the Northern Glaciated Plains, is meeting the criteria for all water quality and field parameters except for fecal coliform bacteria. Beneficial uses listed for the site in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Site T11 is not meeting water quality criteria for beneficial use (8) for fecal coliform bacteria (2000 cfu/100mL (See Figure 98). Based on average daily discharge and seasonal grab sample data, the monitored load as compared to the allowable target load of 2000 cfu/100mL was graphed into five hydrologic zones (See Figure 99). Figure 100 shows the grab samples taken during the study.

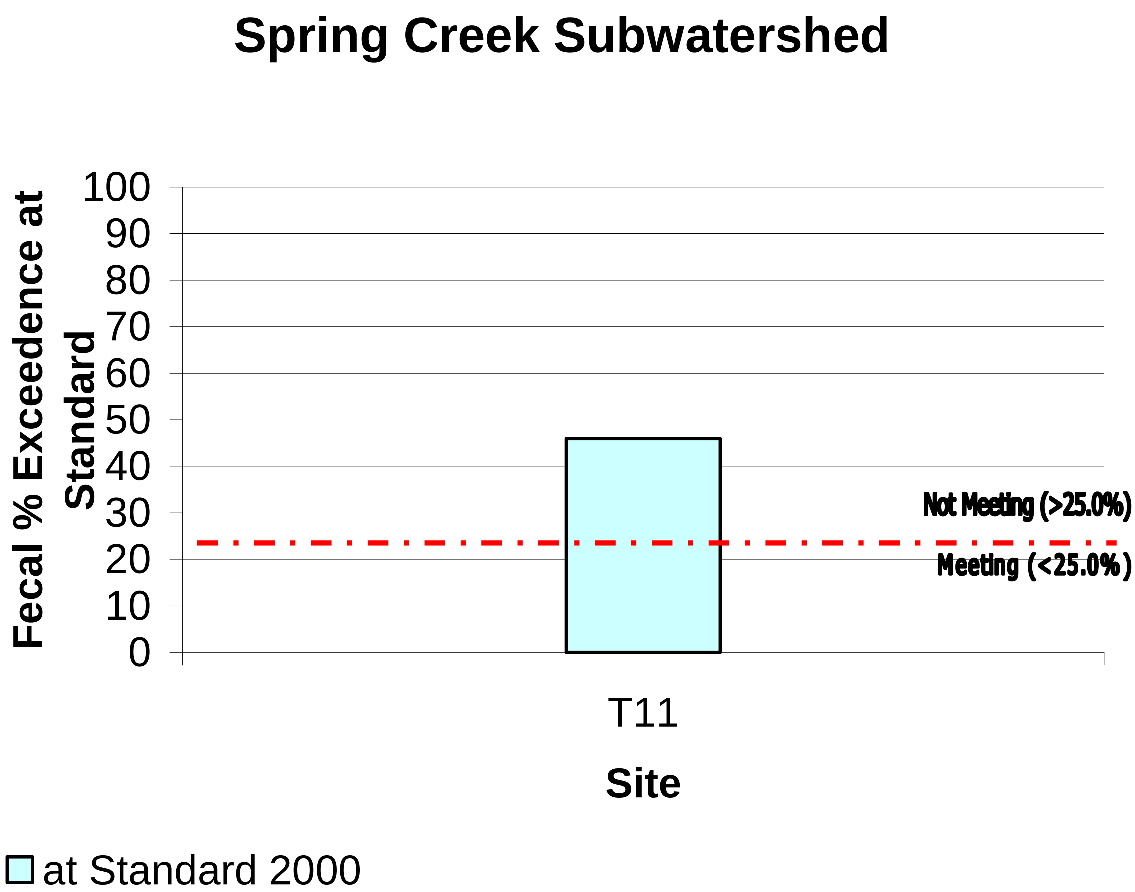


Figure 98. Fecal Coliform Bacteria Percent Exceedence at Standard 2000 cfu/100mL for the Spring Creek Subwatershed

Spring Creek Subwatershed

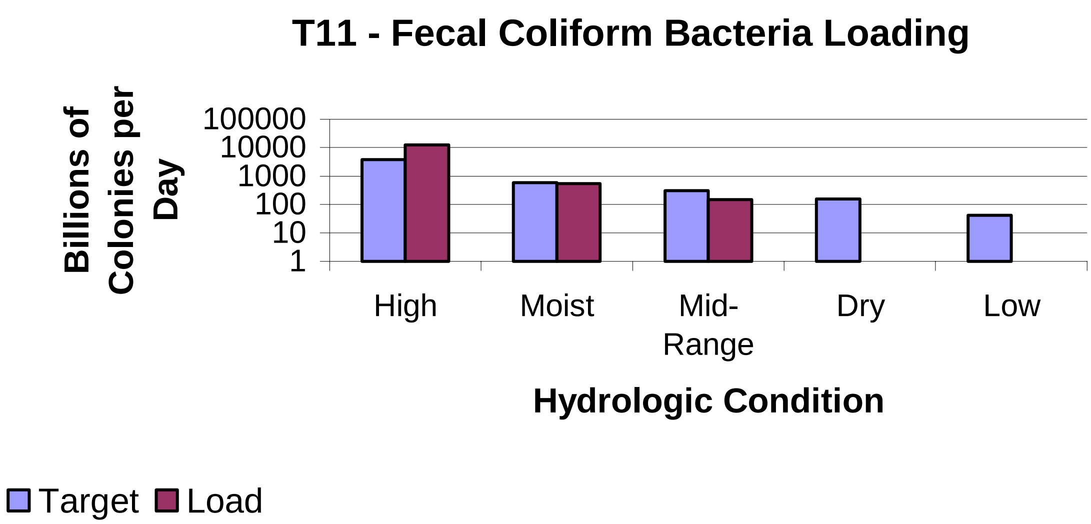


Figure 99. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Spring Creek Subwatershed

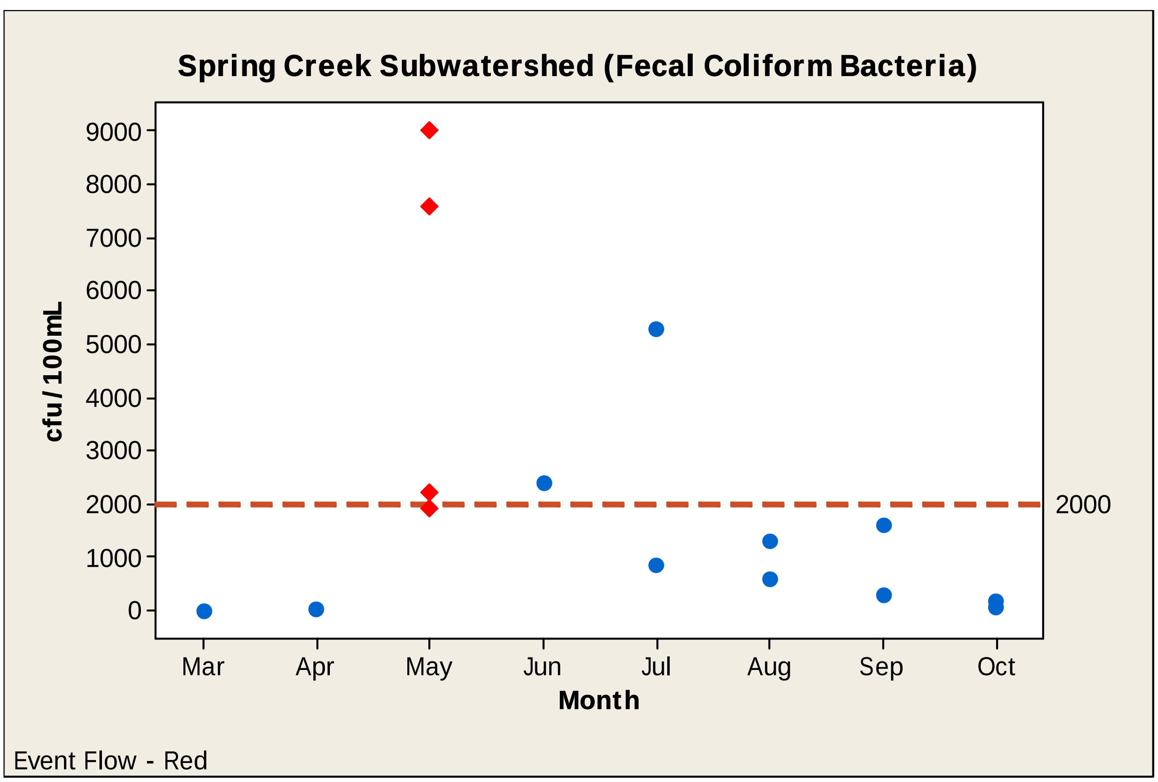


Figure 100. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Spring Creek Subwatershed

Although this subwatershed is meeting the water quality criteria for TSS, Figure 101 is for informational purposes. Based on FLUX model results, Figure 102 shows the estimated TSS loadings for T11 as compared to the standard of 263 mg/L. A scatterplot of the TSS grab samples are shown in Figure 103.

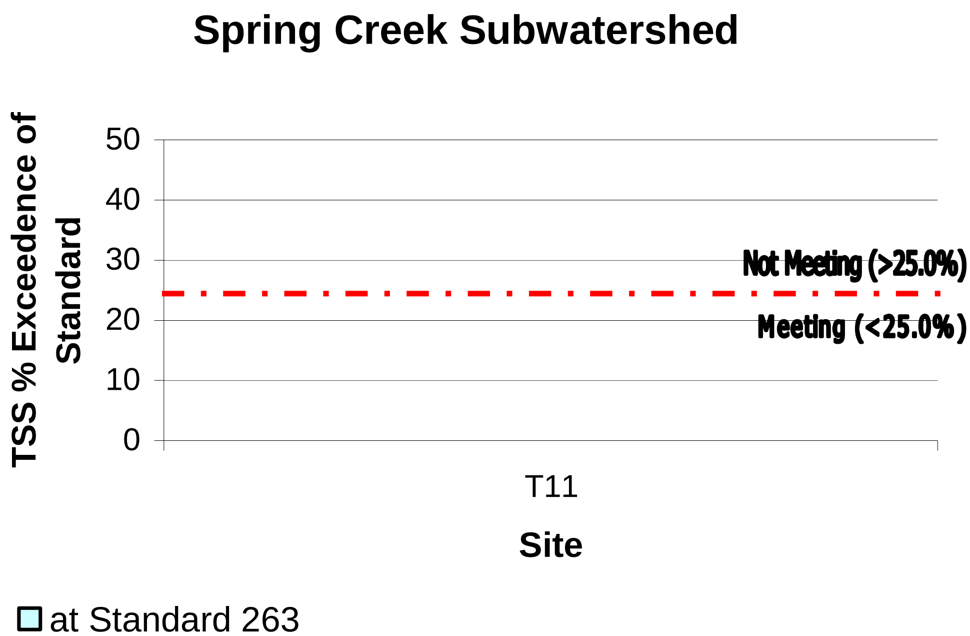


Figure 101. TSS Percent Exceedence at Standard 263 mg/L for the Spring Creek Subwatershed

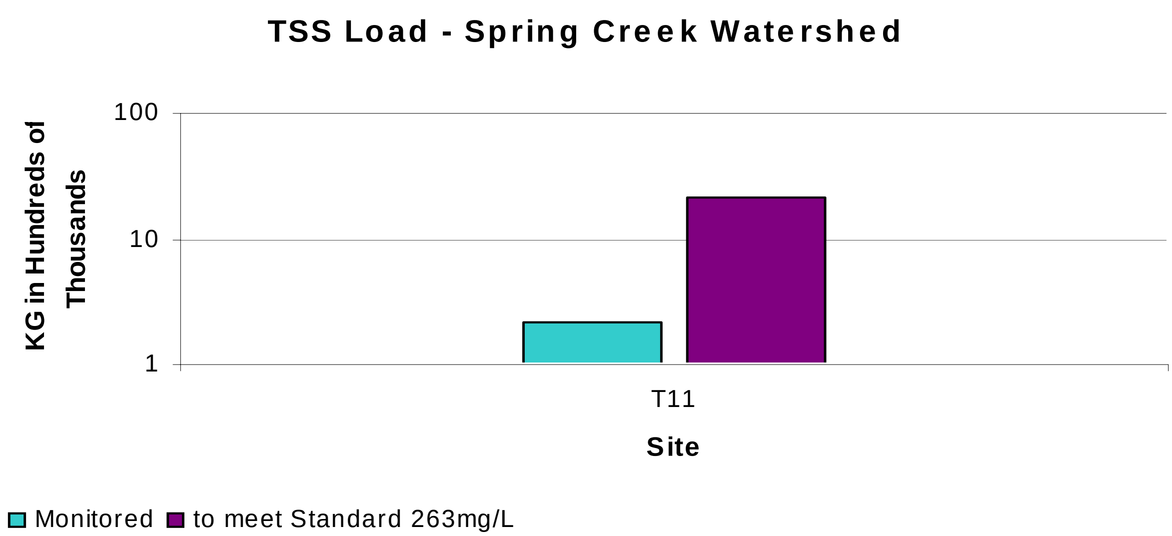


Figure 102. TSS in kg Monitored vs the Standard for the Spring Creek Subwatershed

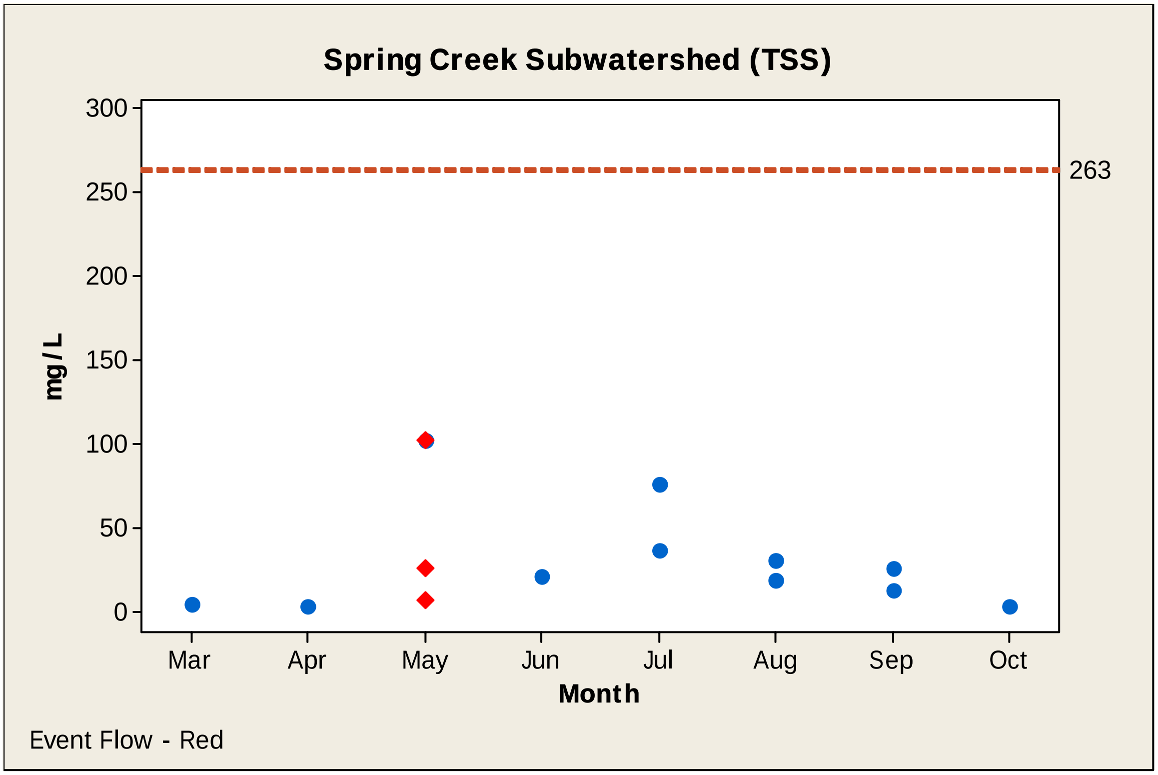


Figure 103. Scatterplot of TSS Grab Samples for the Spring Creek Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, R^2 = 0.9314 (See Figure 104).

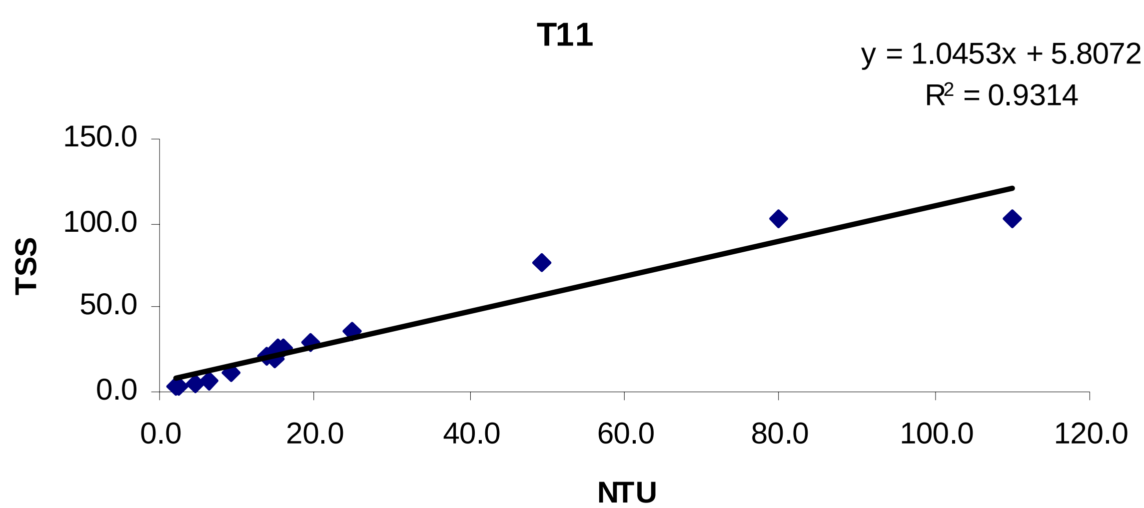


Figure 104. Comparison of TSS and Turbidity for the Spring Creek Subwatershed

The Spring Creek subwatershed meets the water quality criteria for beneficial uses (6) Warmwater Marginal Fish Life Propagation, (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. Fecal coliform bacteria ranged from 270-1900 cfu/100mL with 46 percent violations. TSS ranged from 33-102 mg/L with zero percent violations (See Appendix DD).

The total phosphorus summer mean was 0.19 mg/L, as compared to the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Biological Data Summary

Fish, habitat, and macroinvertebrates were collected in the Spring Creek Subwatershed. Score sheets for this site can be found in Appendix I for fish, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for this site is minimal.

The fish IBI score of 60 was low with minimal numbers of benthic insectivore species and zero sensitive species. The physical habitat scored a 54 due to heavy animal vegetation use and very poor bank stability. Macroinvertebrates scored a 72.

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria would need a reduction of 72 percent in the high flow range. The existing loading as compared to the allowable load for TSS was insignificant and therefore no reduction is needed.

The monitoring data shows higher fecal concentration during runoff along with high exceedences for some of the non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, there are 8 feedlots within this watershed (in South Dakota) with a ranking of ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the non-event flows. Approximately 20 percent of this watershed lies within Lincoln County, Minnesota, which is designated as a wellhead protection area. Lincoln County is in the process of upgrading all the septic systems and feedlots. The town of Elkton, which has a NPDES permit, is the only point source of fecal coliform bacteria. The waste load allocation for Elkton indicated that there is no percent reduction needed. Therefore, the reductions required need to come from non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas section).

Flandreau Creek Subwatershed

This map (Figure 105) shows the area designated as Flandreau Creek Subwatershed and potential for erosion.

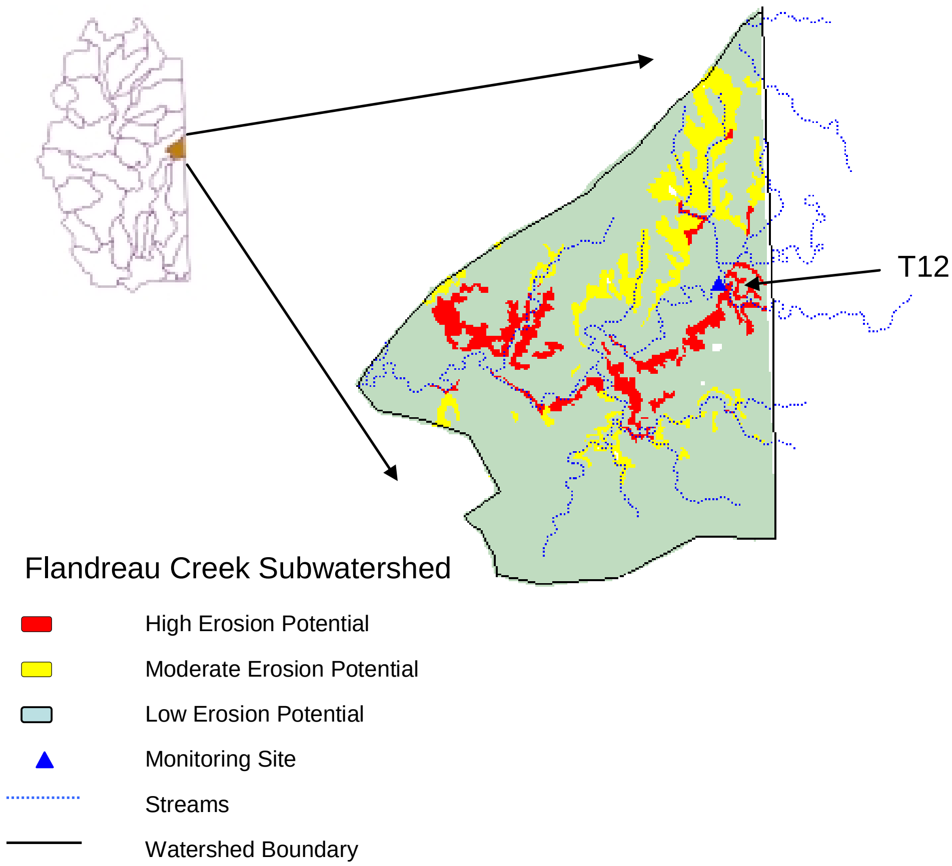


Figure 105. Flandreau Creek Subwatershed Location Map

Land Use Summary

Land use in the South Dakota watershed is predominantly agricultural (Figure 106). Approximately 61 percent of the area is cropland, such as corn and soybeans, and 36 percent is grassland and pastureland. The number of feedlots is unknown due to most of the watershed located in Minnesota.

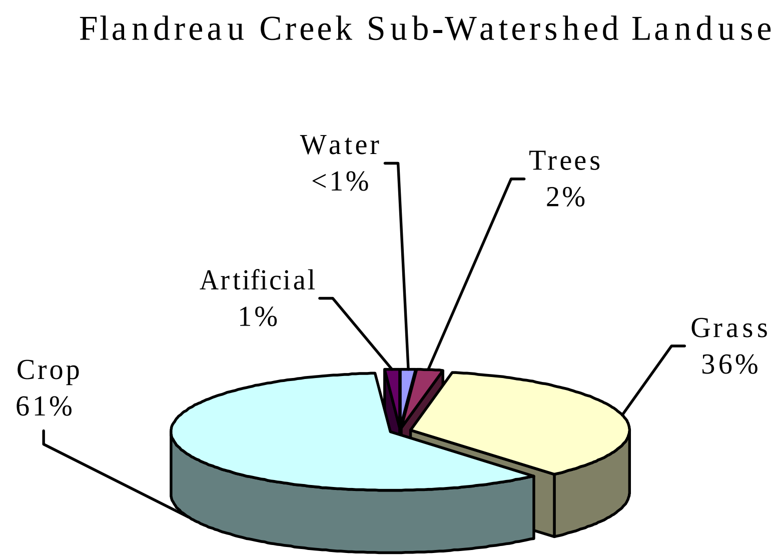


Figure 106. Flandreau Creek Subwatershed Landuse

Water Quality Summary

The Flandreau Creek subwatershed site (T12), located in the Northern Glaciated Plains, is meeting the criteria for all water quality and field parameters except for fecal coliform bacteria. Beneficial uses listed for the site in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Site T12 is meeting water quality criteria for beneficial use (6) Warmwater Marginal Fish Life Propagation, (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. However, for beneficial use (8) Limited Contact Recreation, T12 is not meeting water quality criteria for fecal coliform bacteria (2000 cfu/100mL) (See Figure 107).

Fecal coliform bacteria ranged from 270-10000 cfu/100mL with 36 percent violations. Based on average daily discharge and seasonal grab sample data, the monitored load as compared to the allowable target load of 2000 cfu/100mL was graphed into five hydrologic zones (See Figure 108). Figure 109 shows the grab samples taken during the study.

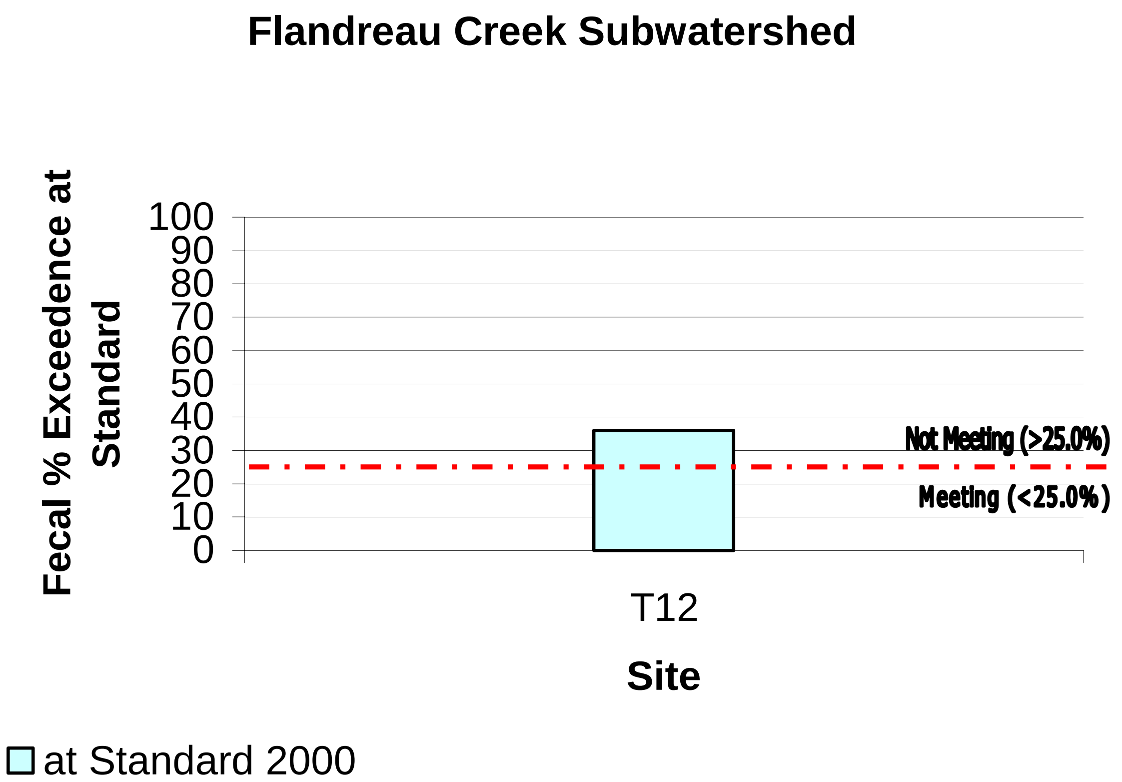


Figure 107. Fecal Coliform Bacteria Percent Exceedence at Standard 2000 cfu/100mL for the Flandreau Creek Subwatershed

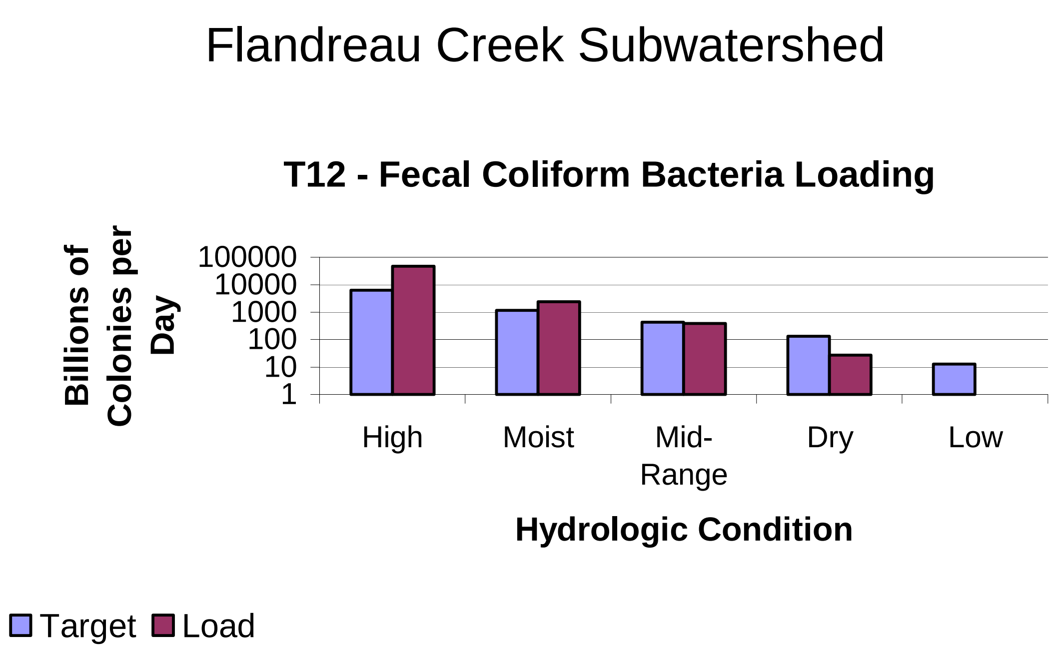


Figure 108. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Flandreau Creek Subwatershed

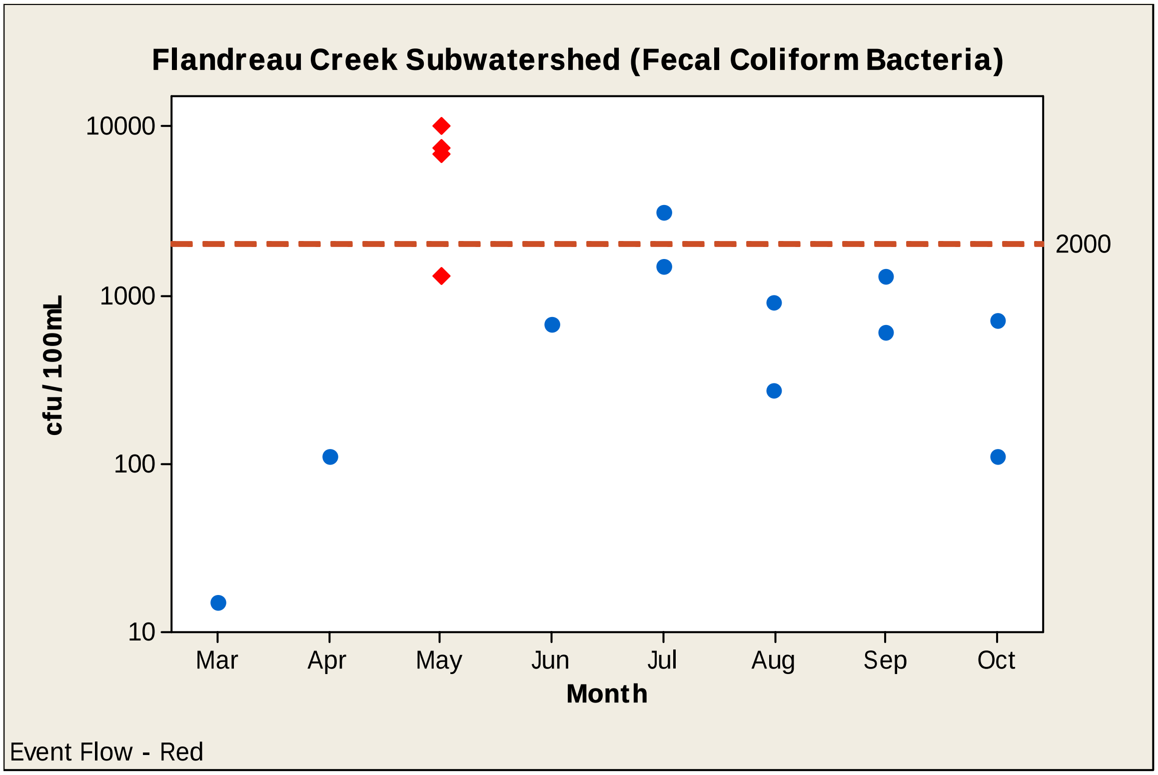


Figure 109. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Flandreau Creek Subwatershed

TSS ranged from 5-308 mg/L with 13 percent violations (See Appendix DD). Although this subwatershed is meeting the water quality criteria for TSS, Figure 110 is for informational purposes. Based on FLUX model results, Figure 111 shows the estimated TSS loadings for T11 as compared to the standard of 263 mg/L. A scatterplot of the TSS grab samples are shown in Figure 112.

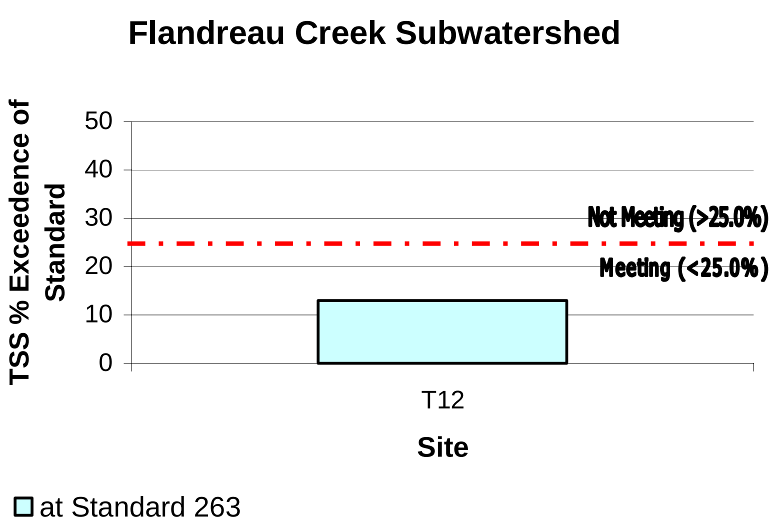


Figure 110. TSS Percent Exceedence at Standard 263 mg/L for the Flandreau Creek Subwatershed

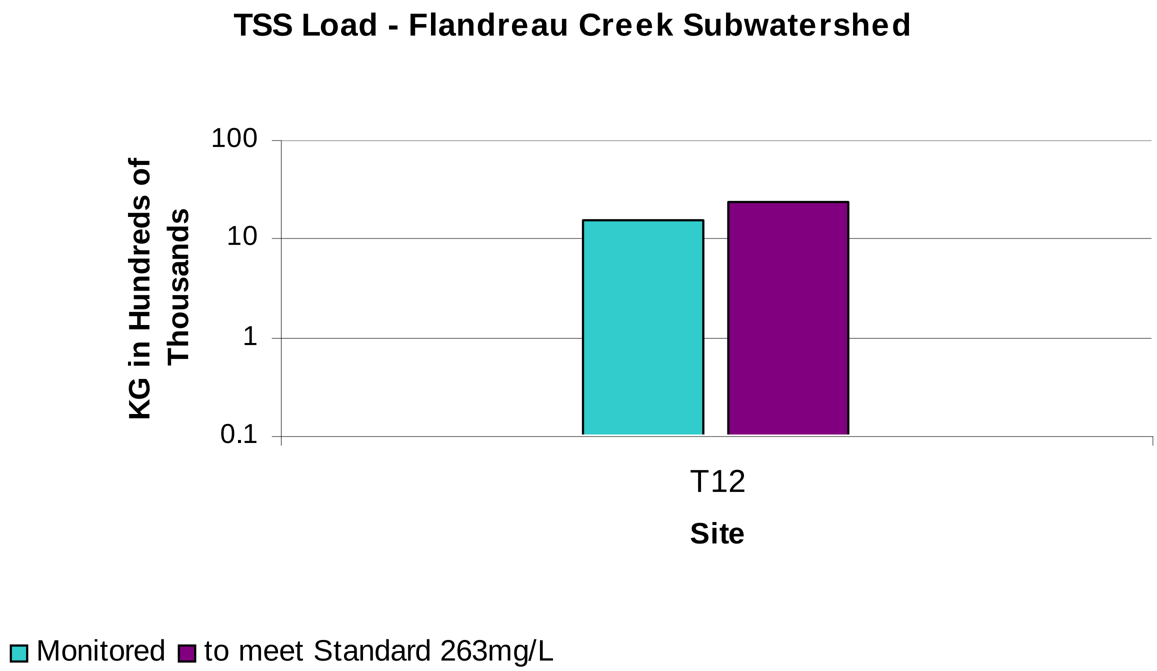


Figure 111. TSS in kg Monitored vs the Standard for the Flandreau Creek Subwatershed

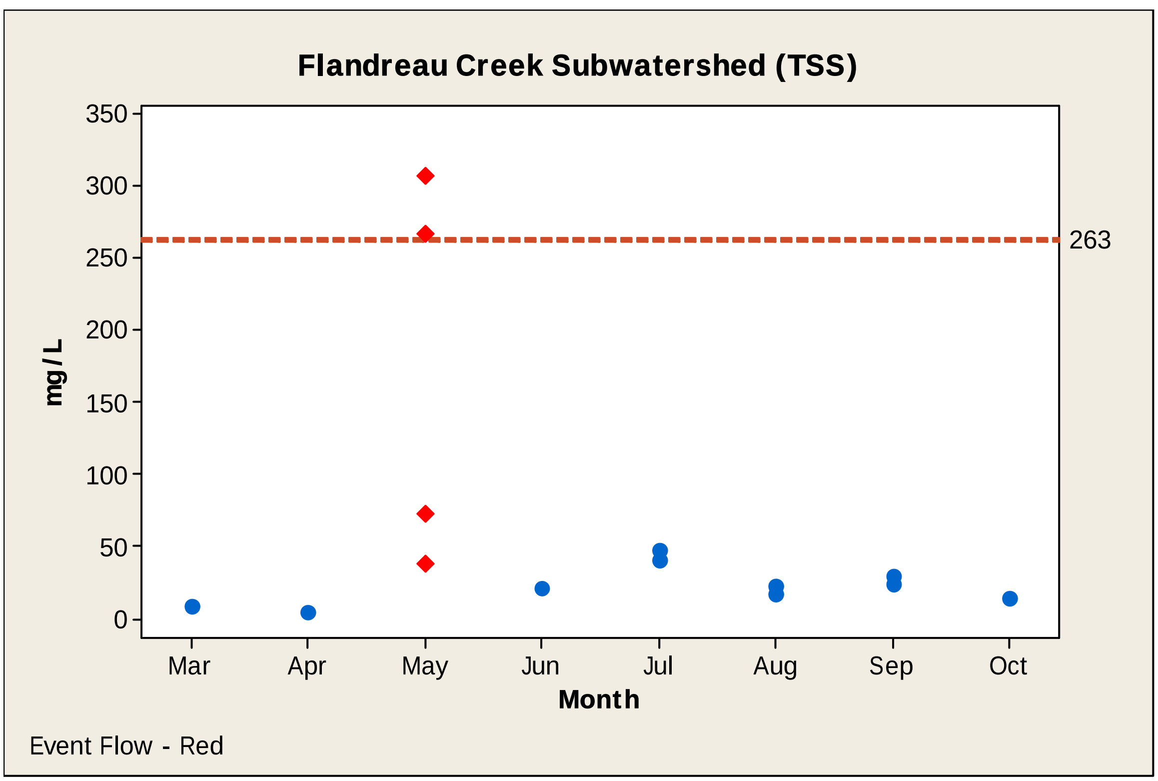


Figure 112. Scatterplot of TSS Grab Samples for the Flandreau Creek Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, R^2 = 0.8486 (See Figure 113).

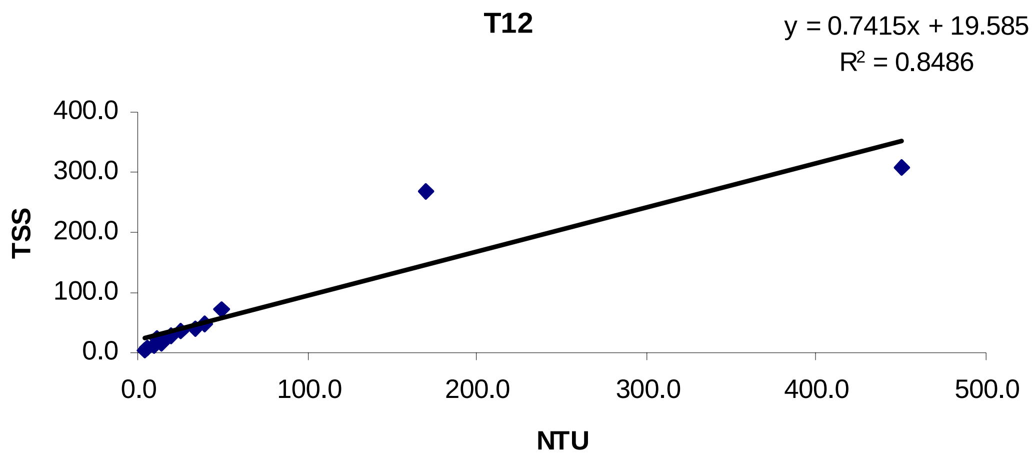


Figure 113. Comparison of TSS and Turbidity for the Flandreau Creek Subwatershed

The Flandreau Creek subwatershed total phosphorus summer mean was 0.3 mg/L, as compared to the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Biological Data Summary

Only macroinvertebrates were collected in the Flandreau Creek Subwatershed. Fishes and physical habitat were not sampled due to dry conditions. Score sheets for this site can be found in Appendix M. Based on the macroinvertebrate data, suggested impairment for this site is minimal. Macroinvertebrate IBI was 75, with high species richness, high Trichop richness, and an HBI of 5.74.

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria would need a reduction of 88 percent in the high flow range and a 55 percent reduction in the moist conditions range (See Appendix BB). The existing load as compared to the allowable load for TSS was insignificant and therefore no reduction is needed.

The monitoring data shows higher fecal concentration during runoff along with some exceedences during the non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. Feedlots below this site (T12) are included in the feedlot inventory for R06. Feedlot data was not provided for this site, since approximately 90 percent of the watershed lies within Minnesota. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the non-event flows. Lake Benton would be the only possible point source of fecal coliform bacteria. They have stabilization ponds and only discharge in early spring and late fall. Therefore, the reductions would need to come from non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas section).

Jack Moore Creek Subwatershed

This map (Figure 114) shows the area designated as Jack Moore Creek Subwatershed and the potential for erosion.

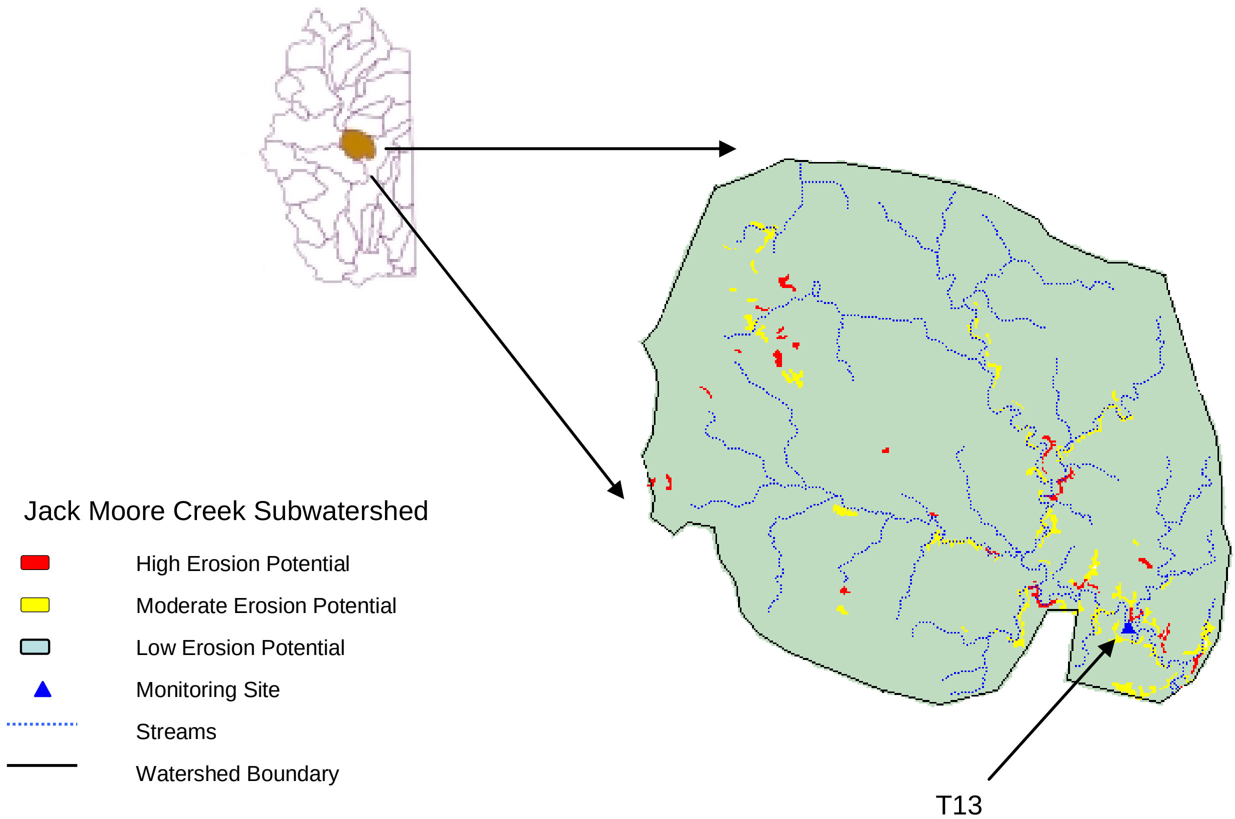


Figure 114. Jack Moore Creek Subwatershed Location Map

Land Use Summary

Land use in the watershed is predominantly agricultural (See Figure 115). Approximately 68 percent of the area is cropland, such as corn and soybeans, and 29 percent is grassland and pastureland. There are no municipalities within this watershed. There were 31 feedlots surveyed in this subwatershed, with 90 percent of the livestock being cattle (See Figure 116).

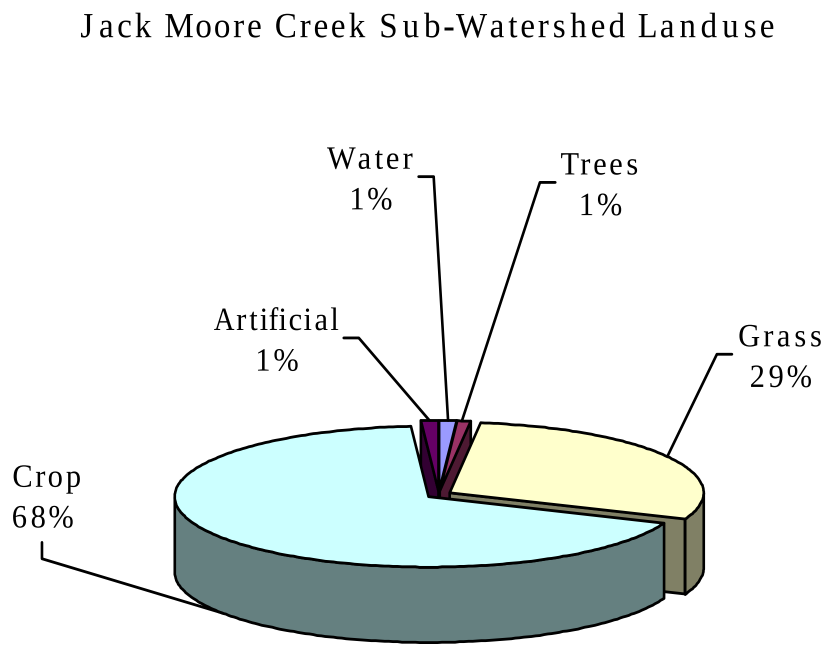


Figure 115. Jack Moore Creek Subwatershed Landuse

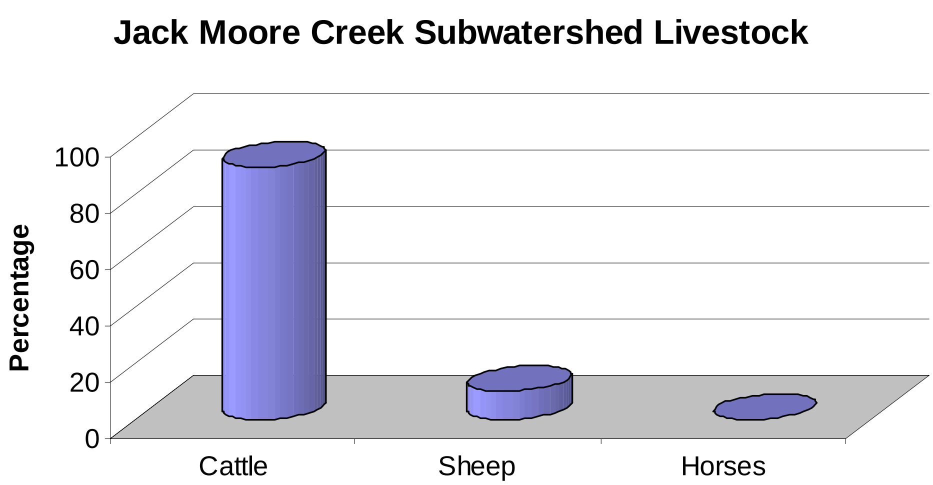


Figure 116. Jack Moore Creek Subwatershed Livestock

Water Quality Summary

The Jack Moore Creek subwatershed site (T13), located in the Northern Glaciated Plains, is meeting the criteria for all water quality and field parameters except for fecal coliform bacteria. Beneficial uses listed for the site in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

T13 is meeting water quality criteria for beneficial use (6) Warmwater Marginal Fish Life Propagation, (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. However, for beneficial use (8) Limited Contact Recreation, T13 is not meeting water quality criteria for fecal coliform bacteria (2000 cfu/100mL) (See Figure 117).

Fecal coliform bacteria ranged from 700-19,000 cfu/100mL with 56 percent violations. Based on average daily discharge and seasonal grab sample data, the monitored load as compared to the allowable target load of 2000 cfu/100mL was graphed into five hydrologic zones (See Figure 118). Figure 119 shows the grab samples taken during the study.

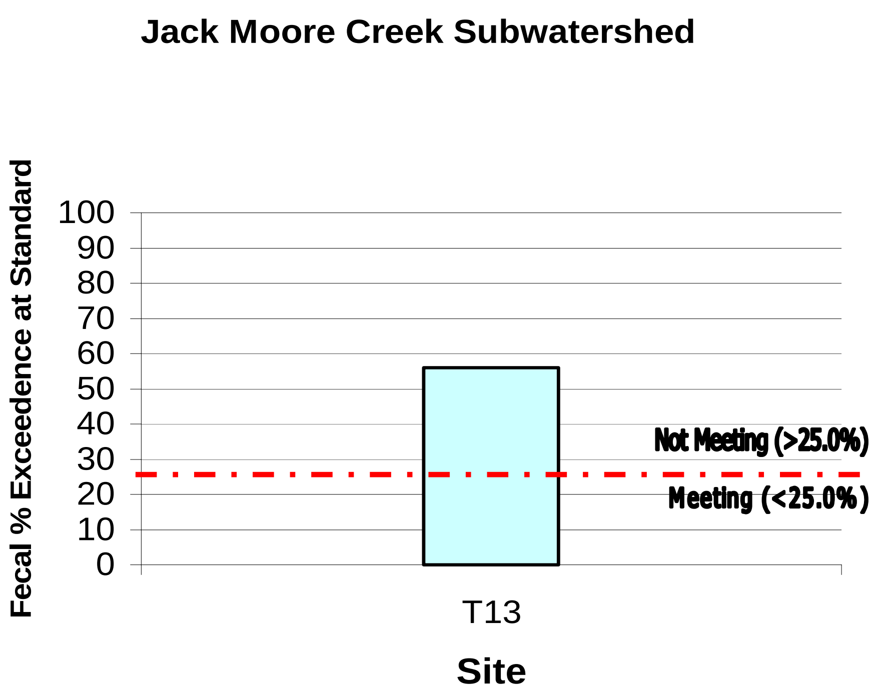


Figure 117. Fecal Coliform Bacteria Percent Exceedence at Standard 2000 cfu/100mL for the Jack Moore Creek Subwatershed

Jack Moore Creek Subwatershed

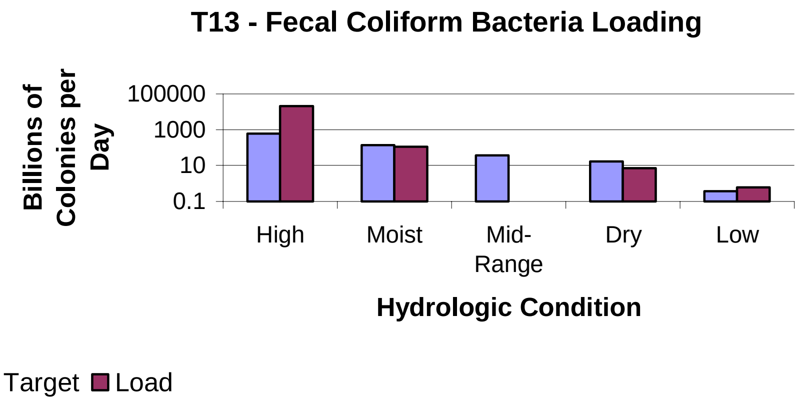


Figure 118. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Jack Moore Creek Subwatershed

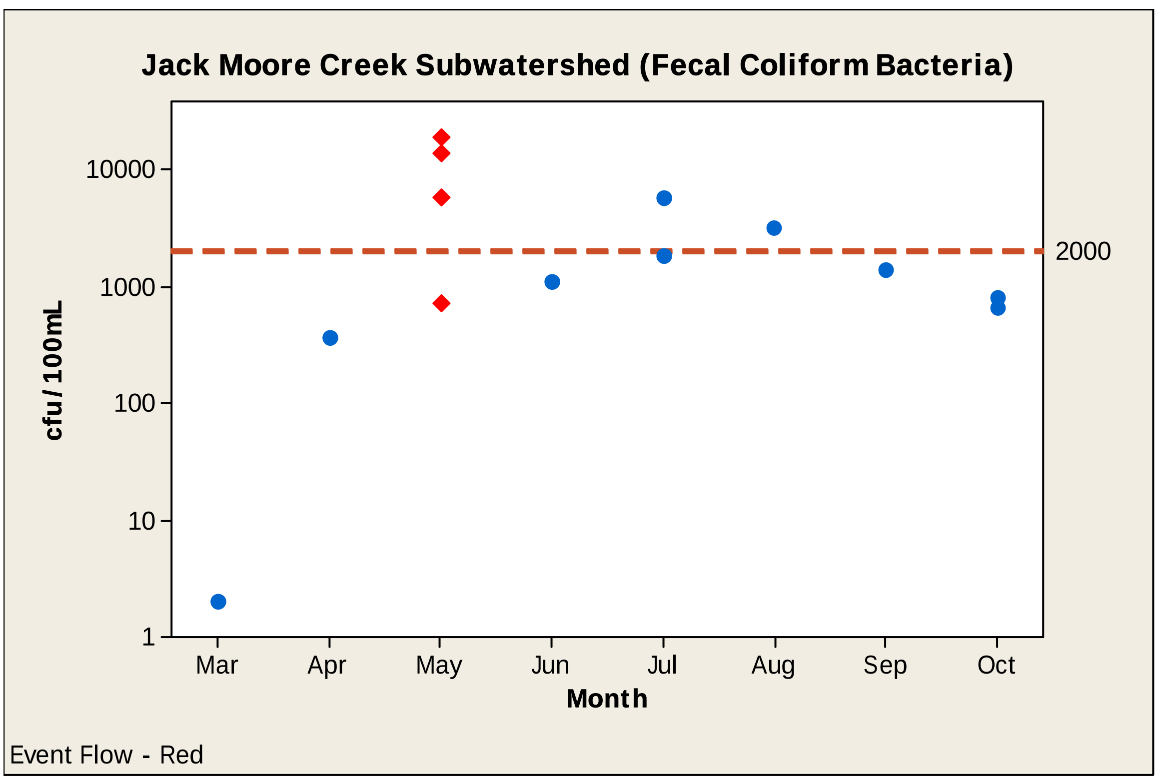


Figure 119. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Jack Moore Creek Subwatershed

TSS ranged from 2-67 mg/L with zero percent violations (See Appendix DD). Although this subwatershed is meeting the water quality criteria for TSS, Figure 120 is for informational purposes. Based on FLUX model results, Figure 121 shows the estimated TSS loadings for T11 as compared to the standard of 263 mg/L. A scatterplot of the TSS grab samples are shown in Figure 122.

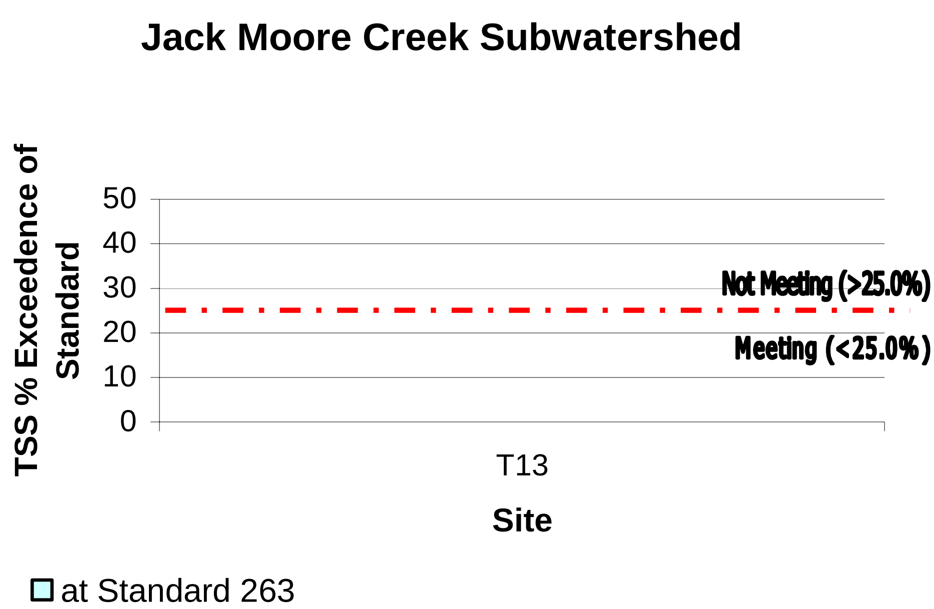


Figure 120. TSS Percent Exceedence at Standard 263 mg/L for the Jack Moore Creek Subwatershed

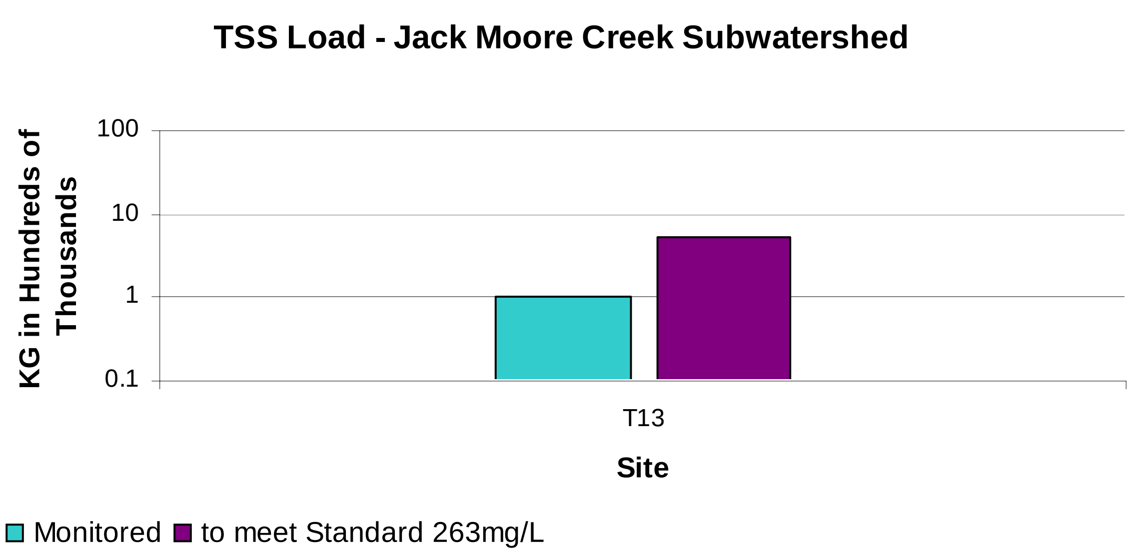


Figure 121. TSS in kg Monitored vs the Standard for the Jack Moore Creek Subwatershed

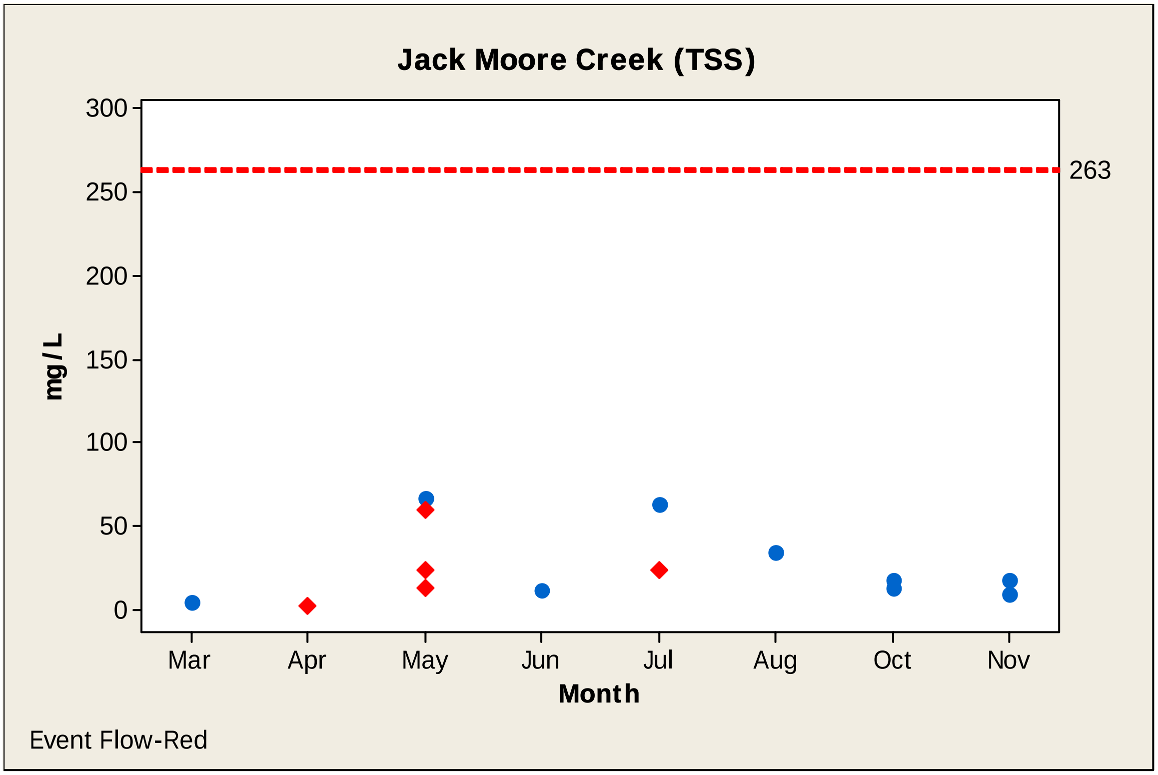


Figure 122. Scatterplot of TSS Grab Samples for the Jack Moore Creek Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, $R^2 = 0.9434$ (See Figure 123).

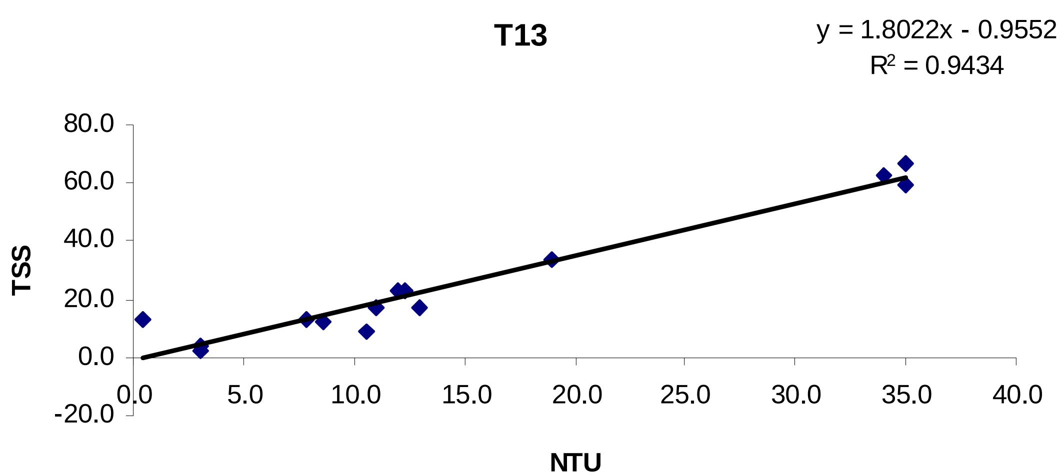


Figure 123. Comparison of TSS and Turbidity for the Jack Moore Subwatershed

The Jack Moore Creek subwatershed total phosphorus summer mean was 0.32 mg/L, as compared to the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Biological Data Summary

Fish, habitat, and macroinvertebrates were collected in the Jack Moore Creek Subwatershed. Score sheets for this site can be found in Appendix I for fishes, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for this site is moderate.

The fish IBI score was 59, with the most abundant species being the Creek Chub. Other notable species included the Orange-spotted Sunfish, Johnny Darter, Common Shiner, and the Sand Shiner. The physical habitat scored a 63, with low animal vegetation use, but lacking in overhanging vegetation. Macroinvertebrates scored a 59, with a low percentage of EPT and low percentages of gatherers and scrapers.

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria would need a reduction of 97 percent in the high flow range and a reduction of 44 percent in the low flow range. The existing loading as compared to allowable for TSS was insignificant and therefore no reduction is needed.

The monitoring data shows higher fecal concentration during runoff and non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, there are 11 feedlots within this watershed with a ranking of ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the non-event flows. There are no identified point sources; therefore, the reductions would need to come from non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas section).

Bachelor Creek Sub-watershed

This map (Figure 124) shows the designated area of Bachelor Creek Subwatershed and the potential for erosion.

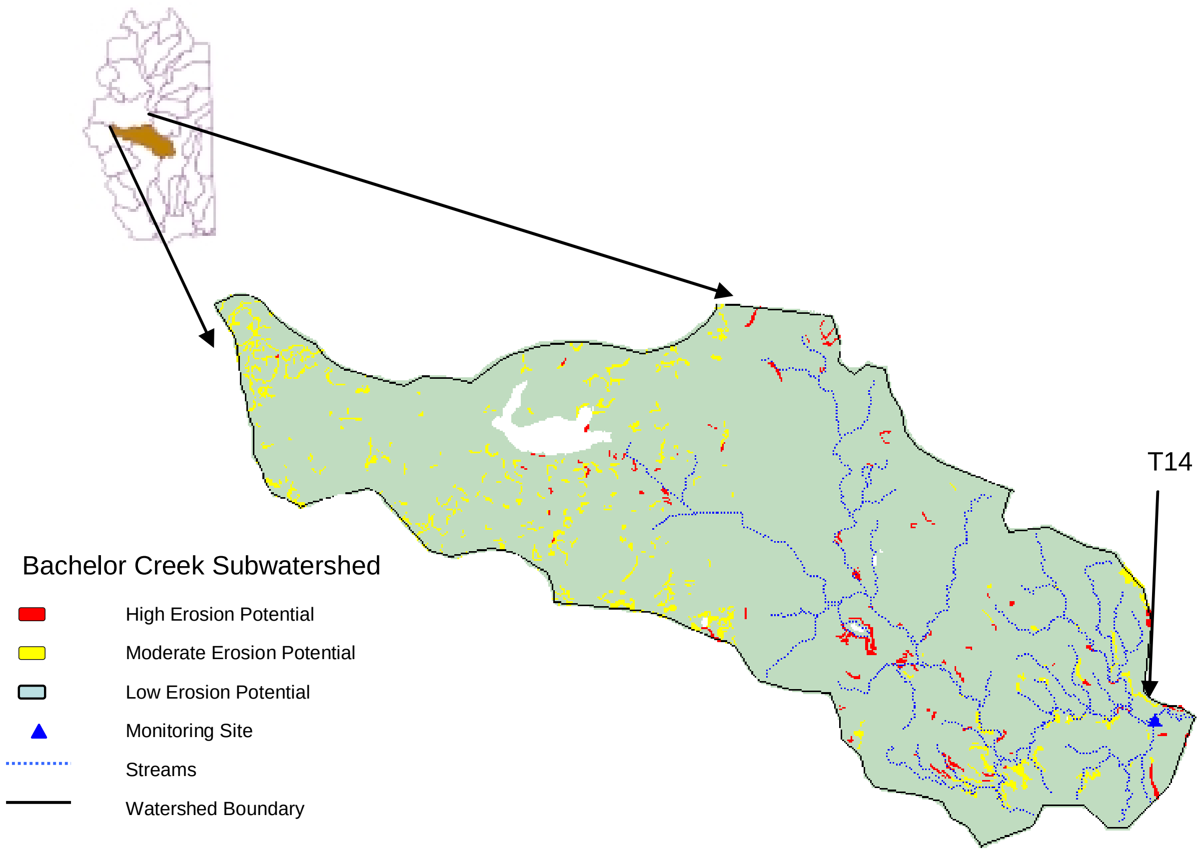


Figure 124. Bachelor Creek Subwatershed Location Map

Land Use Summary

Land use in the watershed is predominantly agricultural (Figure 125). Approximately 67 percent of the area is cropland, such as corn and soybeans, and 27 percent is grassland and pastureland. There are two municipalities within this watershed.

Bachelor Creek Sub-Watershed Landuse

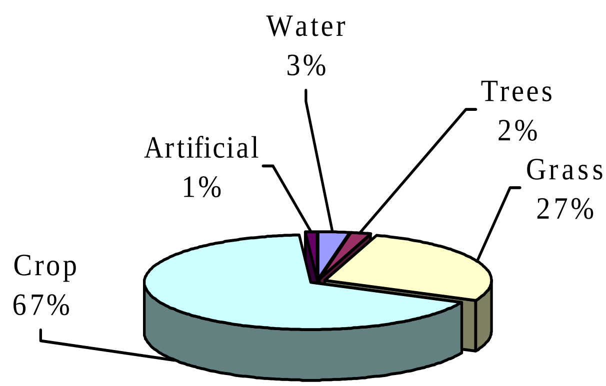


Figure 125. Bachelor Creek Subwatershed Landuse

Water Quality Summary

The Bachelor Creek subwatershed site (T14), located in the Northern Glaciated Plains, is meeting all water quality criteria except for fecal coliform bacteria. Beneficial uses listed for the site in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Site T14 is meeting water quality criteria for beneficial use (6) Warmwater Marginal Fish Life Propagation, (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. However, for beneficial use (8) Limited Contact Recreation, T14 is not meeting water quality criteria for fecal coliform bacteria (2000 cfu/100mL) (See Figure 126).

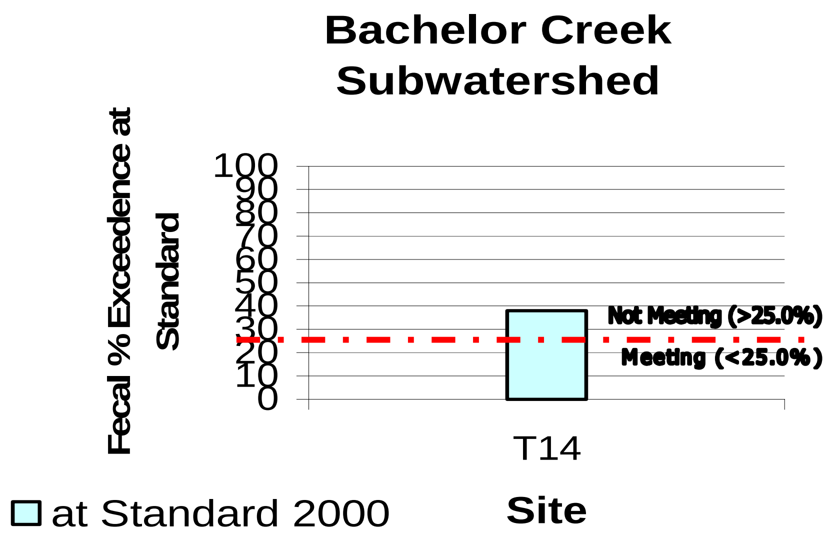


Figure 126. Fecal Coliform Bacteria Percent Exceedence at Standard 2000 cfu/100mL for the Bachelor Creek Subwatershed

Fecal coliform bacteria ranged from 580-55,000 cfu/100mL with 38 percent violations (n=8). Based on average daily discharge and seasonal grab sample data, the monitored load as compared to the allowable target load of 2000 cfu/100mL was graphed into five hydrologic zones (See Figure 127). Figure 128 shows the grab samples taken during the study. Note that eight samples were collected requiring a 100% exceedance rate before a TMDL would be required. Additional monitoring will be used to determine if a TMDL is necessary.

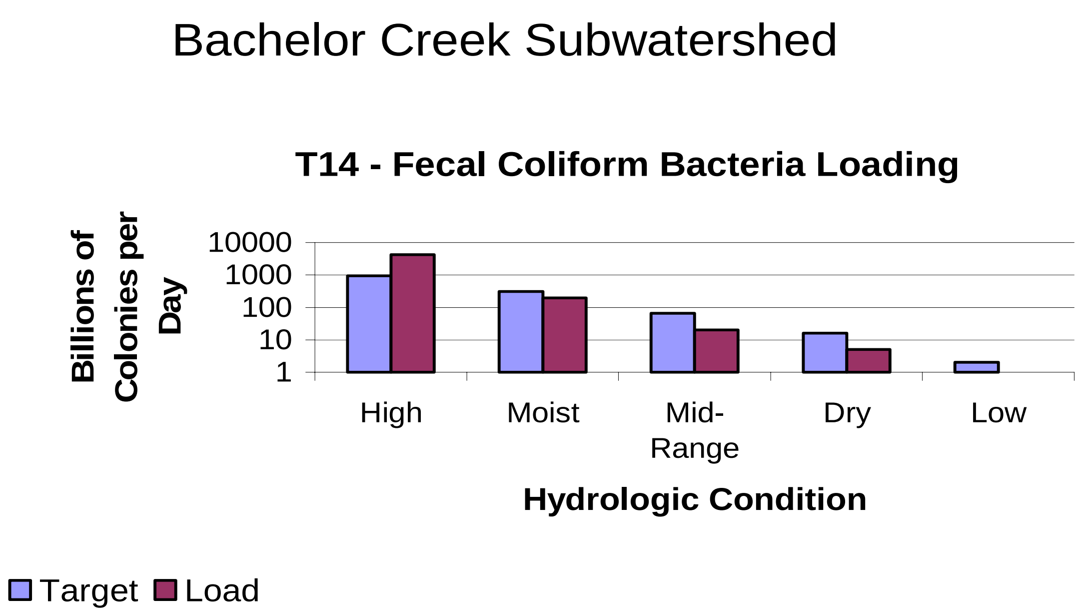


Figure 127. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Bachelor Creek Subwatershed

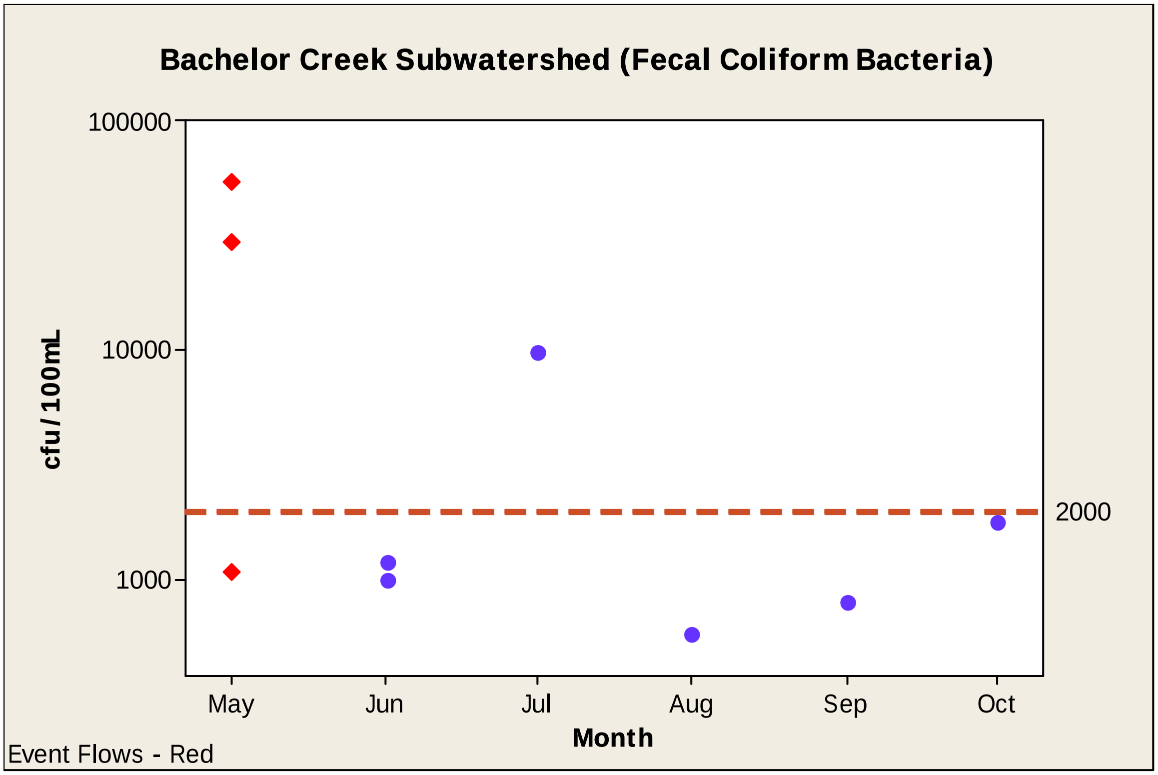


Figure 128. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Bachelor Creek Subwatershed

TSS ranged from 5-266 mg/L with 11 percent violations (See Appendix DD). Although this subwatershed is meeting the water quality criteria for TSS, Figure 129 is for informational purposes. Based on FLUX model results, Figure 130 shows the estimated TSS loadings for T11 as compared to the standard of 263 mg/L. A scatterplot of the TSS grab samples are shown in Figure 131.

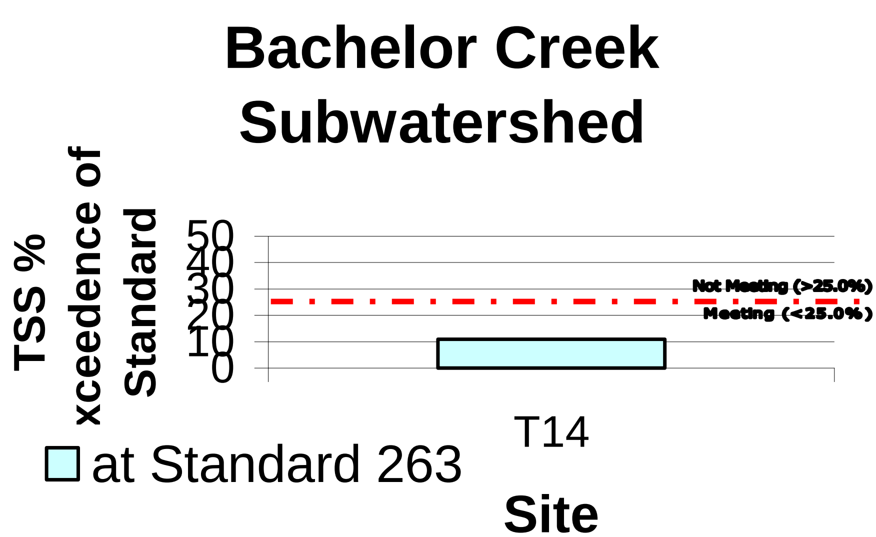


Figure 129. TSS Percent Exceedence at Standard 263 mg/L for the Bachelor Creek Subwatershed

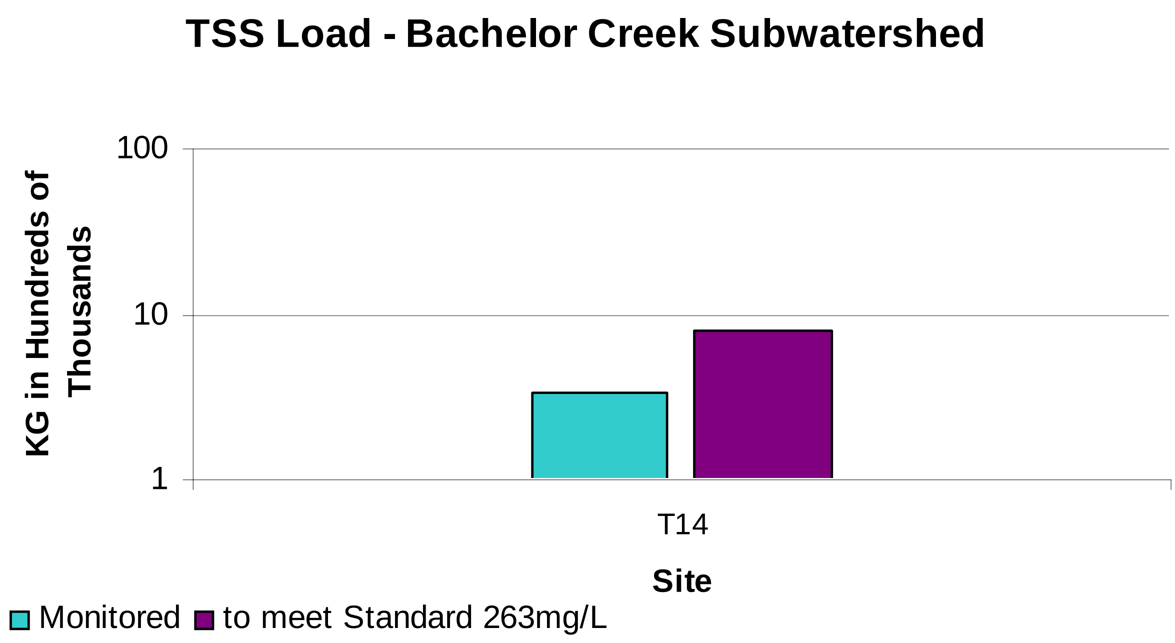


Figure 130. TSS in kg Monitored vs the Standard for the Bachelor Creek Subwatershed

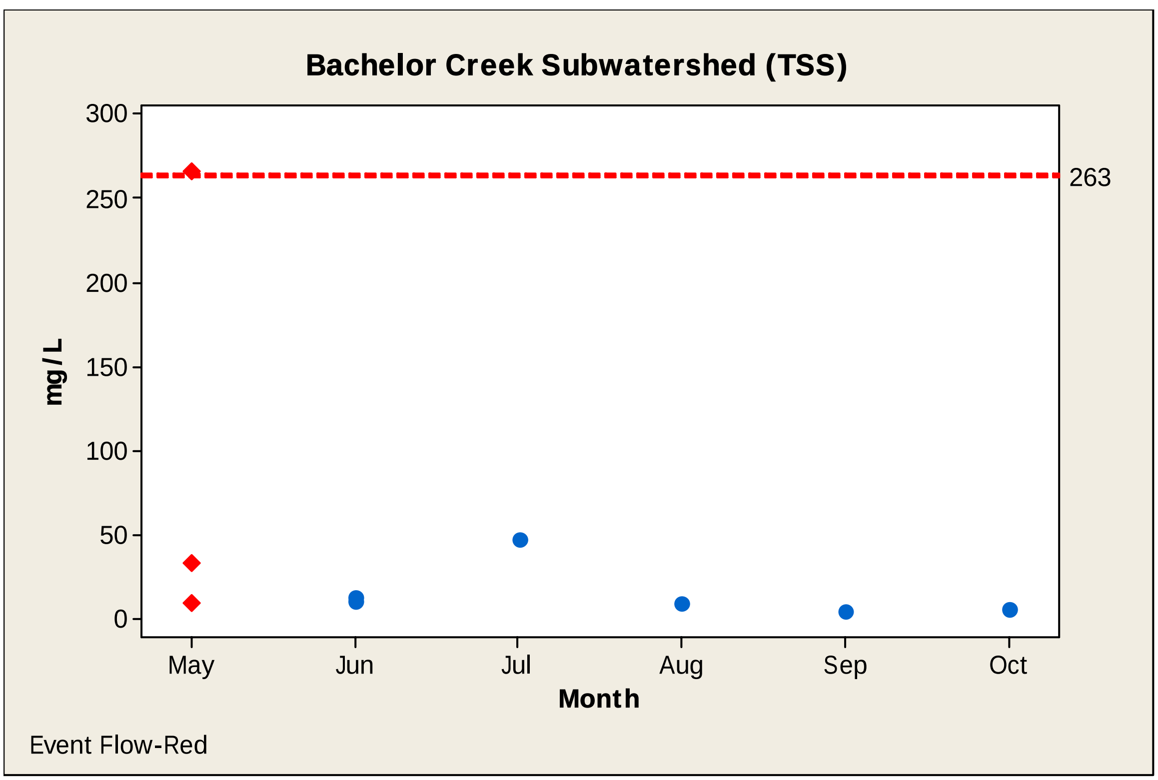


Figure 131. Scatterplot of TSS Grab Samples for the Bachelor Creek Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, R^2 = 0.9914 (See Figure 132).

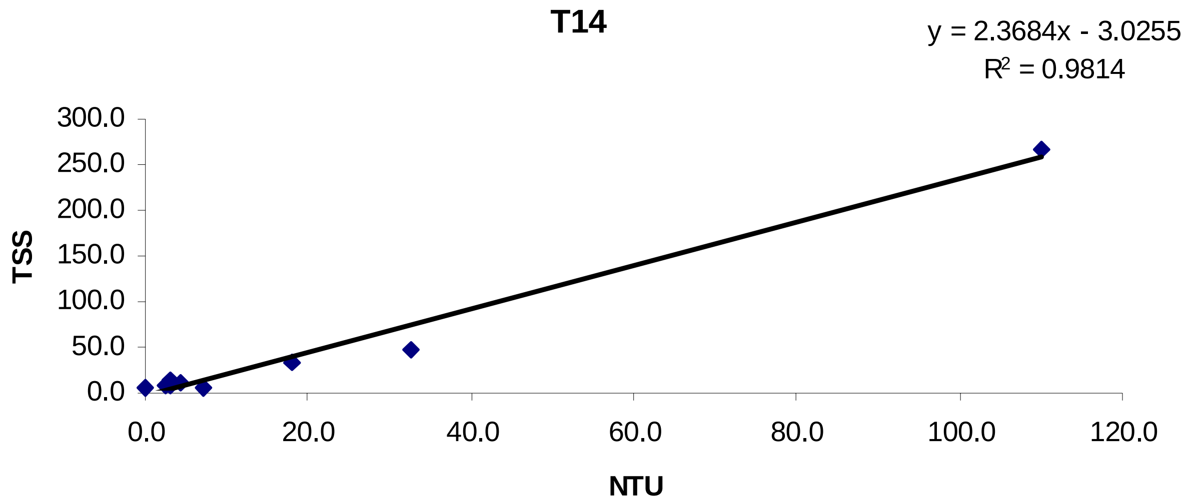


Figure 132. Comparison of TSS and Turbidity for the Bachelor Creek Subwatershed

The Bachelor Creek subwatershed total phosphorus summer mean was 0.26 mg/L, as compared to the ecoregion mean of 0.25 mg/L (Fandrei et al. 1988).

Biological Data Summary

Fish, habitat, and macroinvertebrates were collected in the Bachelor Creek Subwatershed. Score sheets for this site can be found in Appendix I for fish, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for this site is minimal.

The fish IBI has a score of 72, was based on a good percentage of insectivorous minnows and pioneer species. There were very high numbers of Sand Shiners and Bigmouth Shiners, with good numbers of Red Shiners and Creek Chubs.

The physical habitat scored a 70 and exhibited excellent physical complexity, fairly good bank stability and overhanging vegetation, and low animal vegetation use. Similarly, macroinvertebrates scored a 65 with an HBI of 4.66 and a high percentage of Chironomidae and gatherers.

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria would need a reduction of 80 percent in the high flow range. However, the number of samples (n=8) and resulting violations (n=3) do not exceed the 2006 DENR listing methodology threshold requiring a TMDL. Additional monitoring should be conducted.

The existing TSS loading, when compared to the allowable load for TSS, was insignificant and therefore no reduction is needed.

The monitoring data shows higher fecal concentration during runoff and some exceedences during non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. See the Bachelor Creek Assessment report (Troelstrup and Larson 2000) for feedlot inventory. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the non-event flows. There are two municipalities, Wentworth and Colman, located in this watershed. Wentworth is NPDES permitted and has total retention.

This subwatershed already has a watershed assessment completed entitled Phase I Watershed Assessment Final Report, Bachelor Creek, Moody County, South Dakota (Troelstrup and Larson 2000). For further discussion or recommendations, see more detailed data in the previous mentioned report.

Silver Creek Subwatershed

This map (Figure 133) shows the area designated as Silver Creek Subwatershed and the potential for erosion.

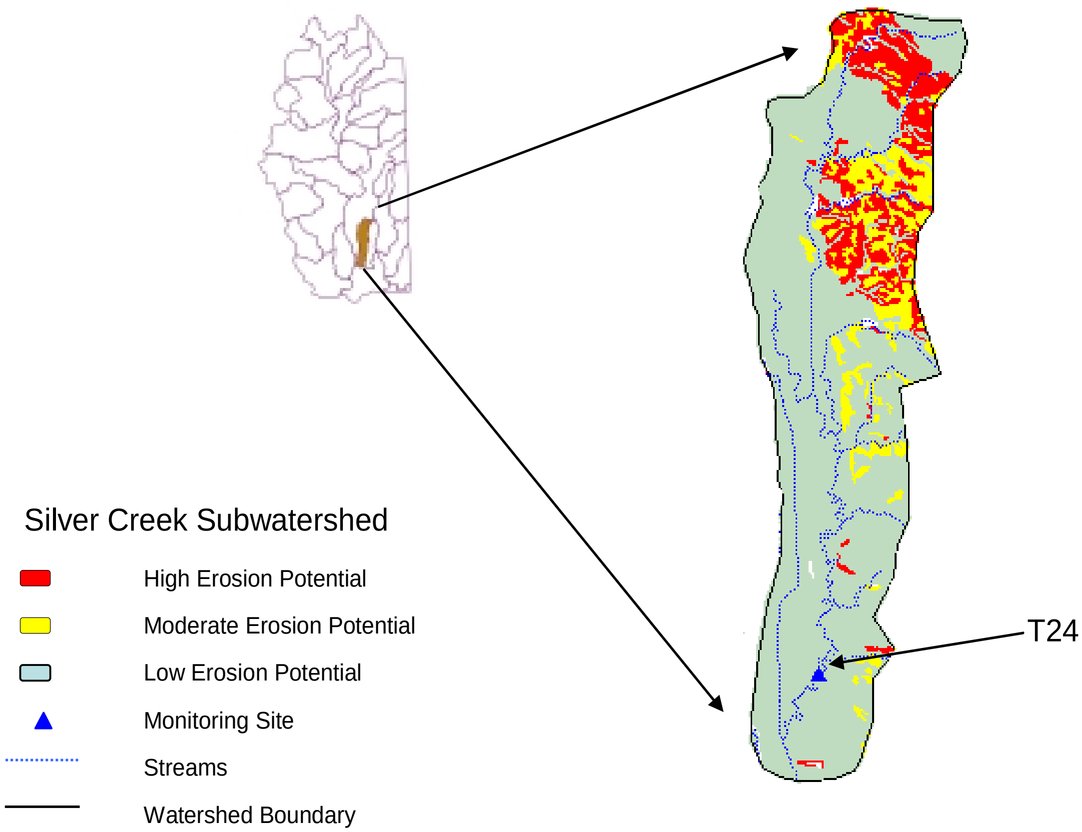


Figure 133. Silver Creek Subwatershed Location Map

Silver Creek Sub-Watershed Land Use

Land use in the watershed is predominantly agricultural (Figure 134). Approximately 68 percent of the area is cropland, such as corn and soybeans, and 29 percent is grassland and pastureland. There are no municipalities within this watershed. There were 12 feedlots surveyed in this watershed, with 60 percent of the livestock being pigs (See Figure 135).

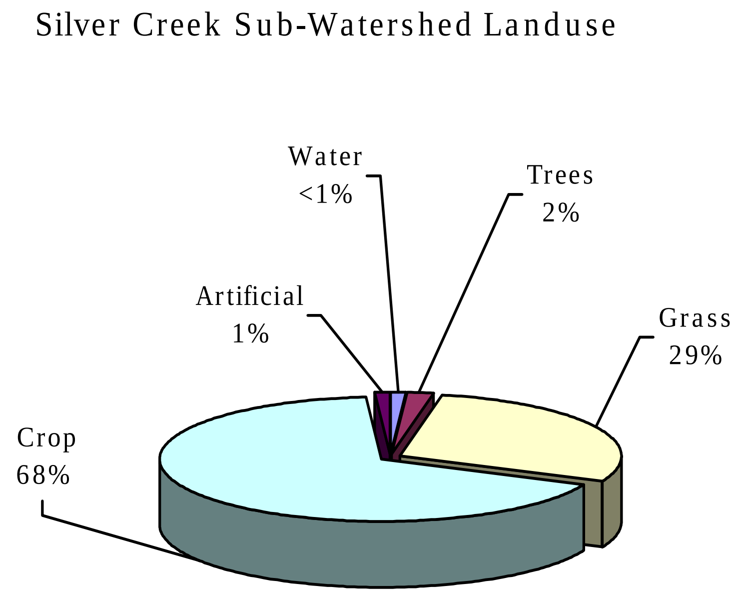


Figure 134. Silver Creek Subwatershed Landuse

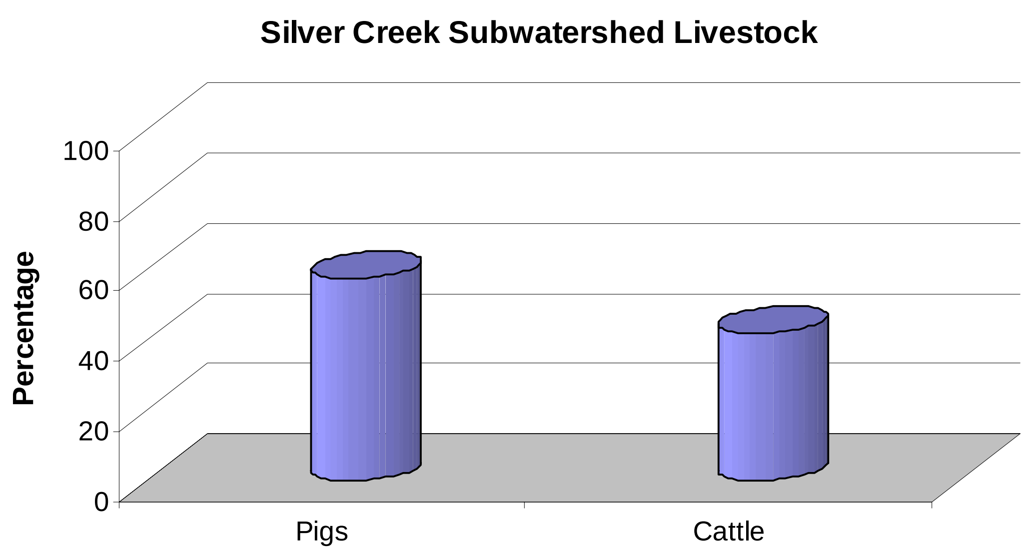


Figure 135. Silver Creek Subwatershed Livestock

The Silver Creek subwatershed site (T24), located in the Western Cornbelt Plains, is meeting the water quality criteria associated with its beneficial uses (refer to Table 6 for each sites beneficial use):

(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

Site T24 is meeting water quality criteria for beneficial use (9) Fish and Wildlife Propagation, Recreation, and Stock Watering, and (10) Irrigation. The more stringent beneficial uses found on the Big Sioux River

(5) Warmwater Semipermanent Fish Life Propagation , and (8) Limited Contact Recreation are also used to determine contributing sources to the mainstem segments. Dissolved oxygen collected from Site T24 ranged from 3.5 mg/L to 8.6 mg/L. If Silver Creek had an additional fishery or human contact uses establishing a DO standard of ≥ 5 mg/L, Silver Creek would exhibit a 36 percent exceedance rate (Figure 136). A scatterplot of the DO grab samples are shown in Figure 137. The data here are shown for implementation purposes only.

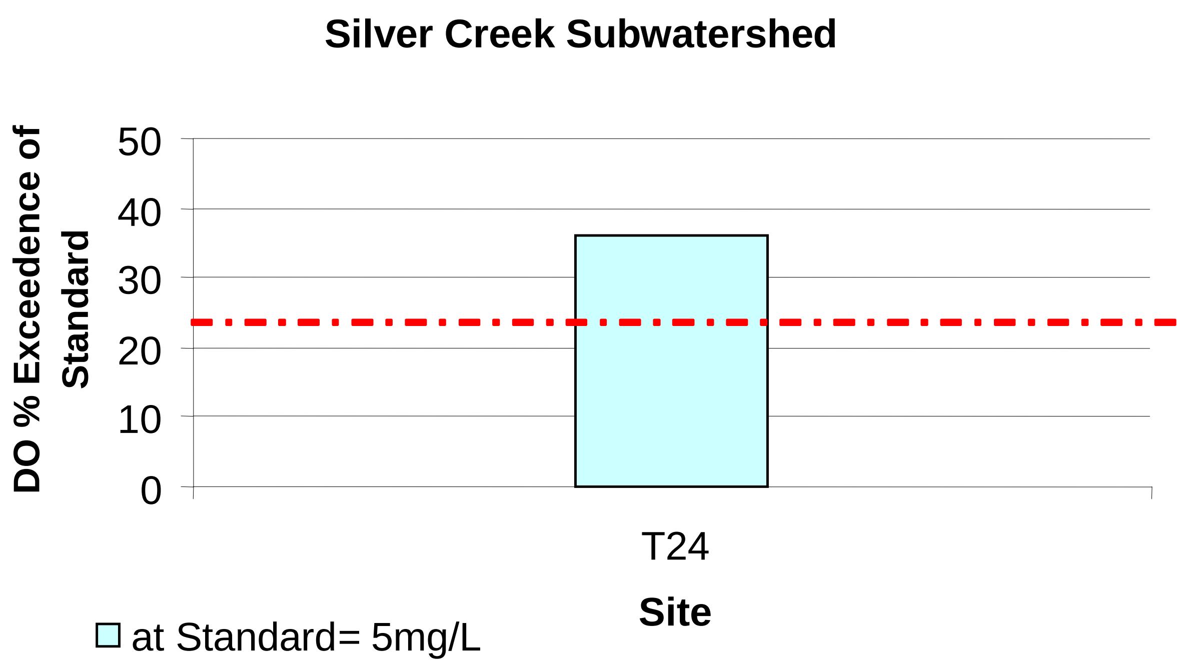


Figure 136. Dissolved Oxygen Percent Exceedence at Standard ≥ 5 mg/L for the Silver Creek Subwatershed (for informational purposes only)

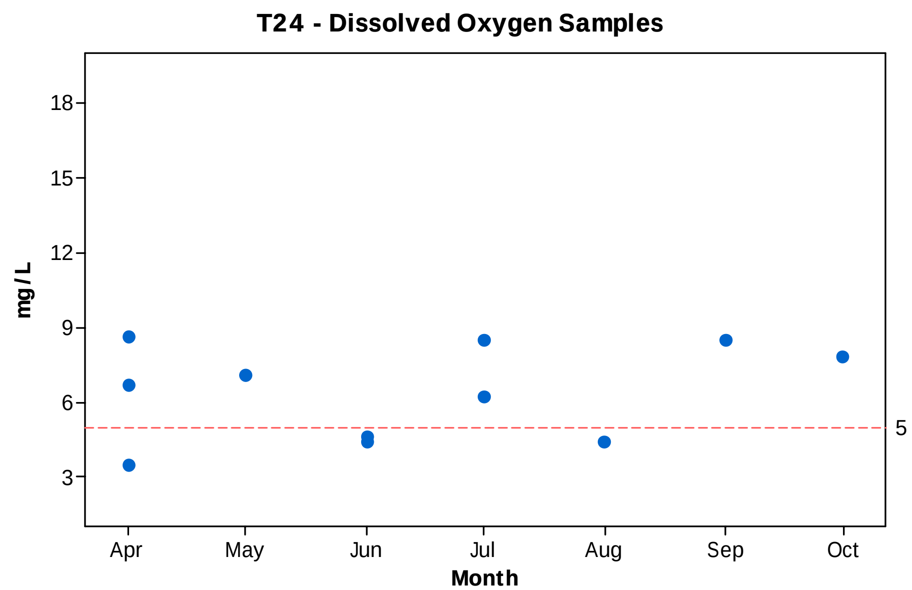


Figure 137. Scatterplot of Dissolved Oxygen Samples for the Silver Creek Subwatershed

Figure 138 is for informational purposes. TSS ranged from 1-270 mg/L (See Appendix DD). Based on FLUX model results, Figure 139 shows the estimated TSS loadings for T24 as compared to the standard of 263 mg/L. A scatterplot of the TSS grab samples are shown in Figure 140.

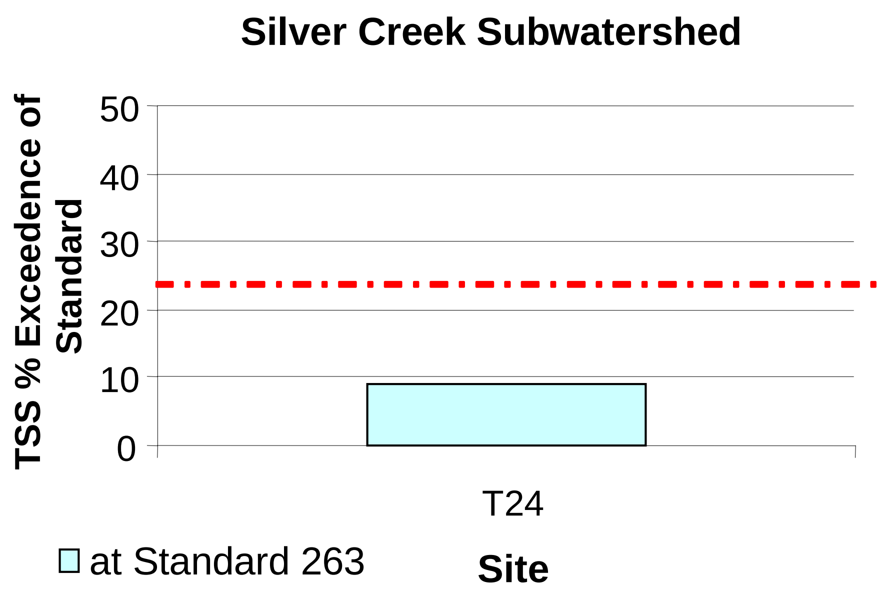


Figure 138. TSS Percent Exceedence at Standard 263 mg/L for the Silver Creek Subwatershed (for informational purposes only)

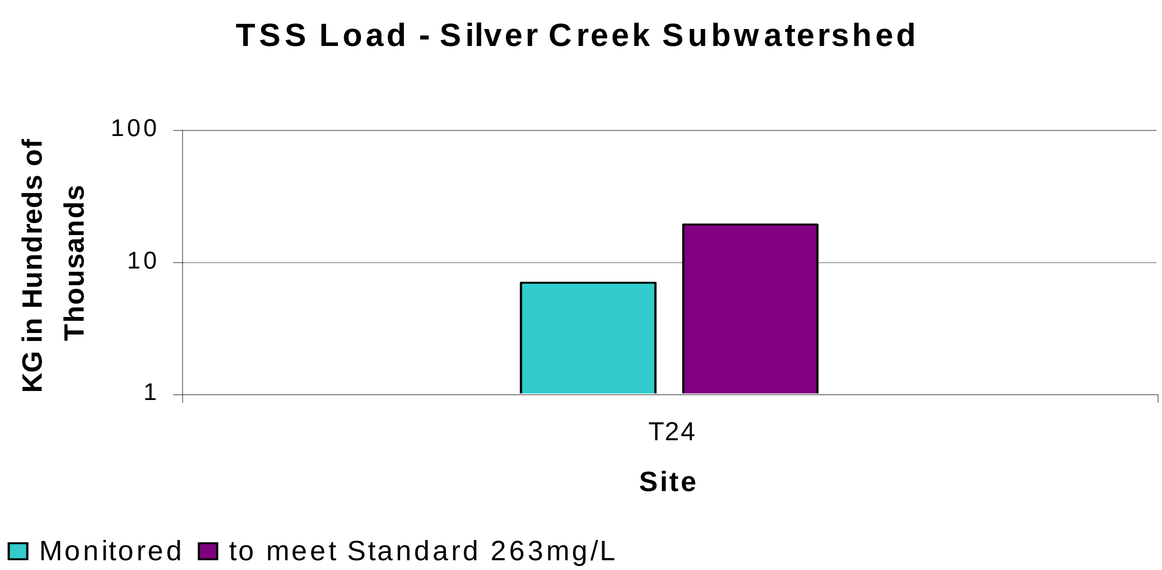


Figure 139. TSS in kg Monitored vs the Standard for the Silver Creek Subwatershed (for informational purposes only)

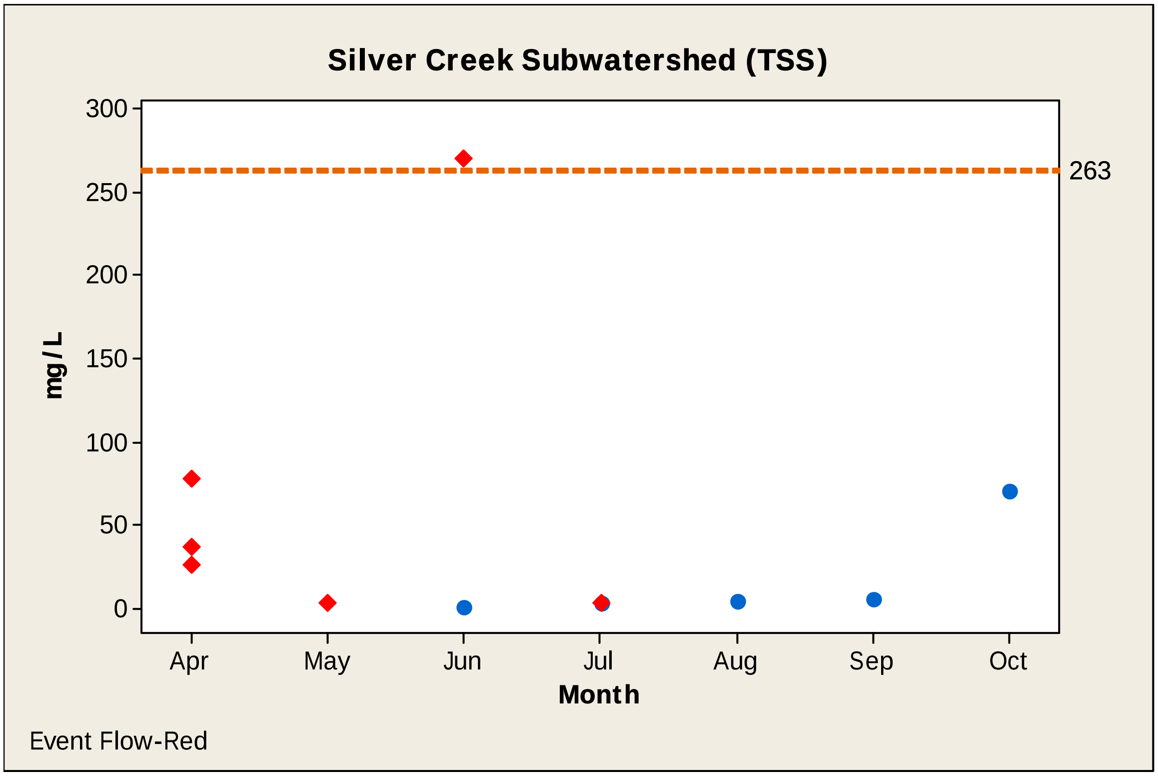


Figure 140. Scatterplot of TSS Grab Samples for the Silver Creek Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, R^2 = 0.9300 (See Figure 141).

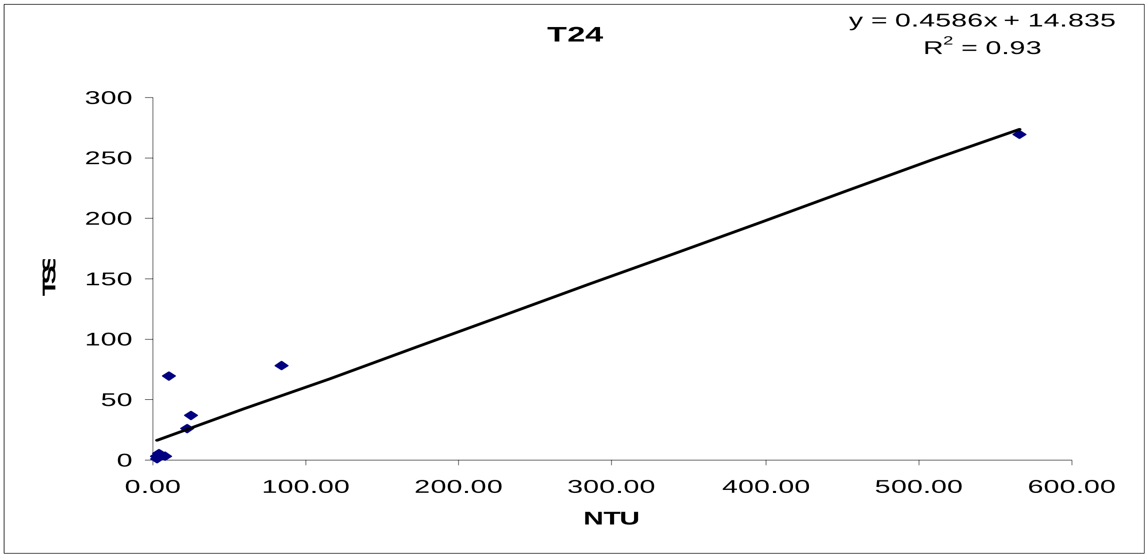


Figure 141. Comparison of TSS and Turbidity for the Silver Creek Subwatershed

Figure 142 is for informational purposes only. Fecal coliform bacteria ranged from 30-22,000 cfu/100mL. Based on average daily discharge and seasonal grab sample data, the monitored load as compared to a target load calculated using 2000 cfu/100mL for informational purposes, was graphed into five hydrologic zones (See Figure 143). Figure 144 shows the grab samples taken during the study.

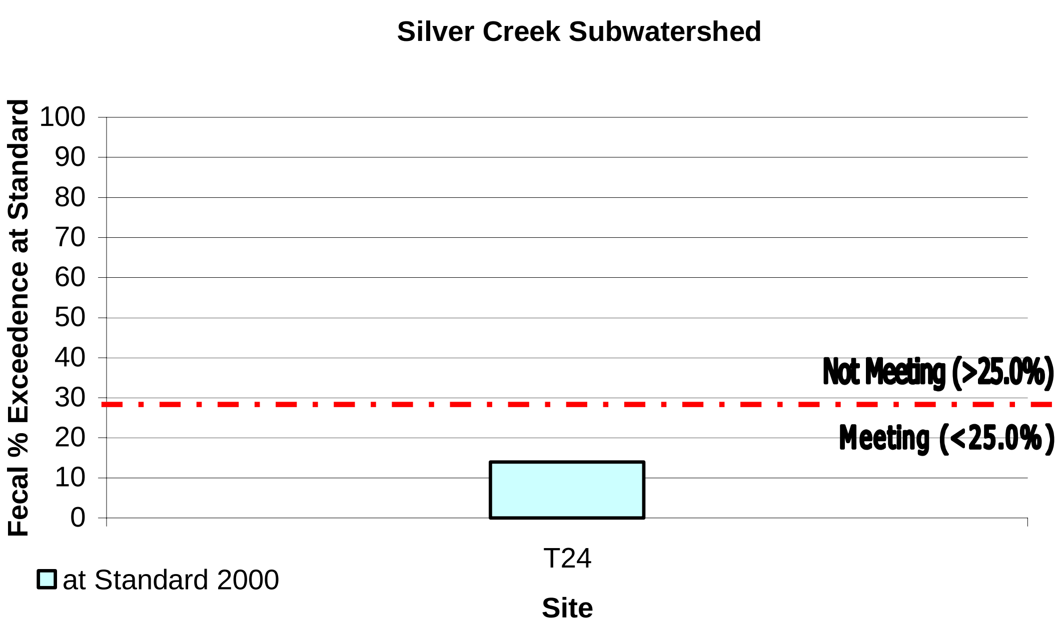


Figure 142. Fecal Coliform Bacteria Percent Exceedence at Standard 2000 cfu/100mL for the Silver Creek Subwatershed

Silver Creek Subwatershed

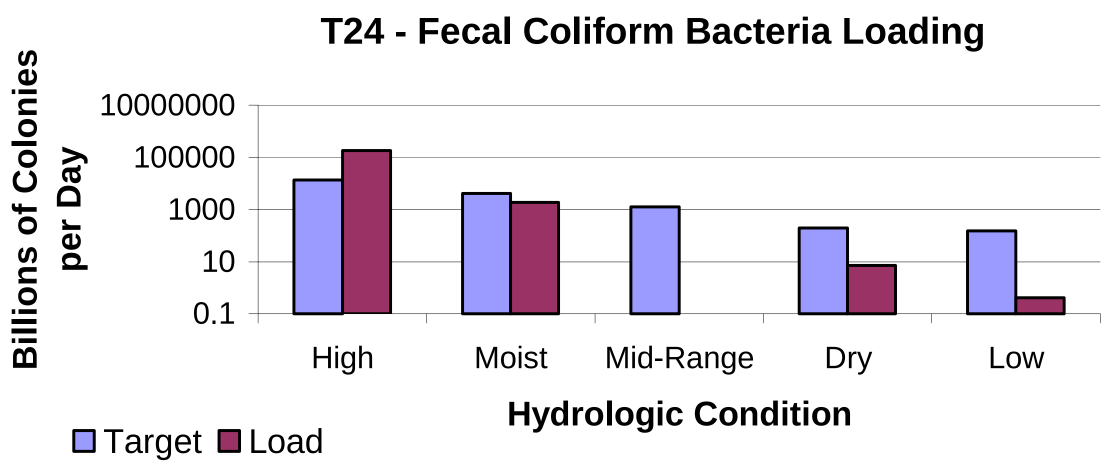


Figure 143. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Silver Creek Subwatershed (for informational purposes)

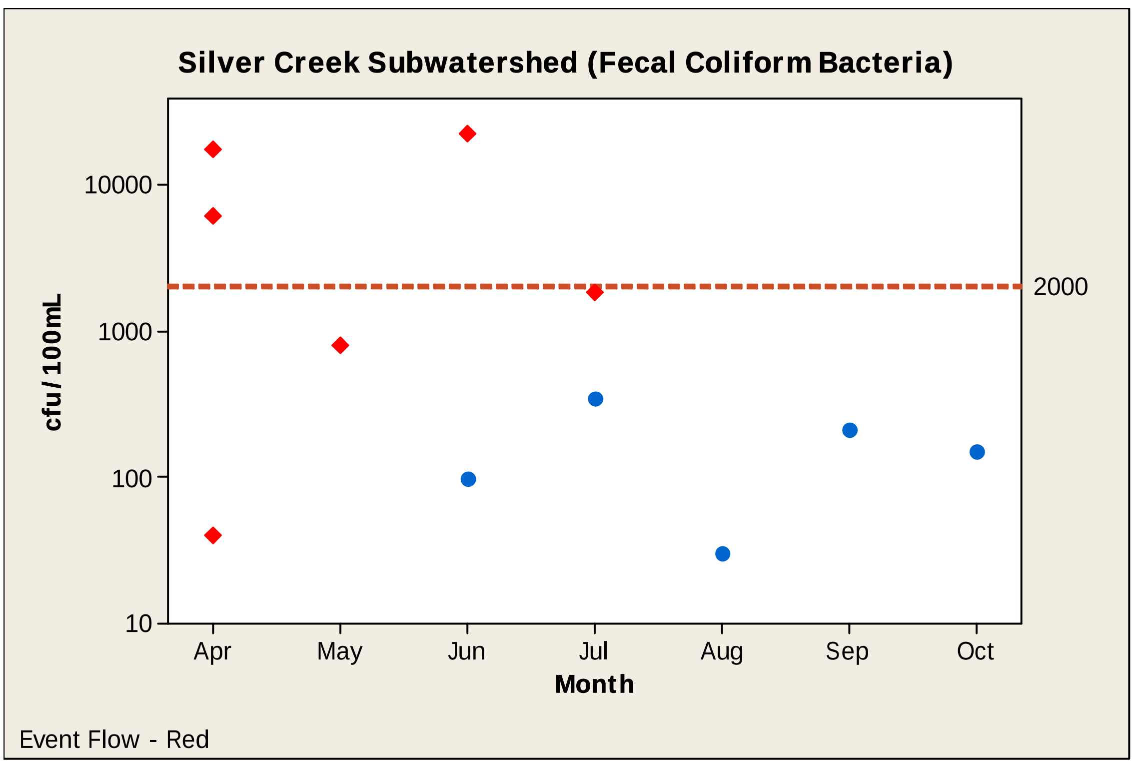


Figure 144. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Silver Creek Subwatershed

The Silver Creek subwatershed total phosphorus summer mean was 0.49 mg/L, as compared to the ecoregion mean of 0.30 mg/L (Fandrei et al. 1988).

Biological Data Summary

Only macroinvertebrates were collected in the Silver Creek Subwatershed. Fish and physical habitat were not sampled due to dry conditions. Score sheets for the macroinvertebrates can be found in Appendix M. Based on the macroinvertebrate data, suggested impairment for this site is moderate. The macroinvertebrates scored a 57. Although the HBI was 7.61, the more sensitive scrapers and clingers were not abundant and there were a high percentage of tolerant organisms.

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria would need a reduction of 93 percent in the high flow range. The existing loading for TSS was insignificant and therefore no reduction is recommended.

The monitoring data shows higher fecal concentration during runoff events only. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, there is two feedlot within this watershed with a ranking of ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. There are no identified point sources; therefore, the reductions would need to come from non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas section).

Four of the eleven DO samples were less than ≥ 5.0 mg/L. Low DO levels may be attributed to heavy algae growth due to excessive nutrients, stagnant water or very low flows, and higher water temperatures. At this time there is insufficient DO data to conclude that this creek has a DO problem. Therefore, additional monitoring would be necessary. As stated earlier, Silver Creek's summer phosphorus mean was 0.49 mg/L, which is higher than the suggested ecoregion mean of 0.30 mg/L.

Slip-Up Creek Subwatershed

This map (Figure 145) shows the area designated as Slip-Up Creek Subwatershed and the potential for erosion.

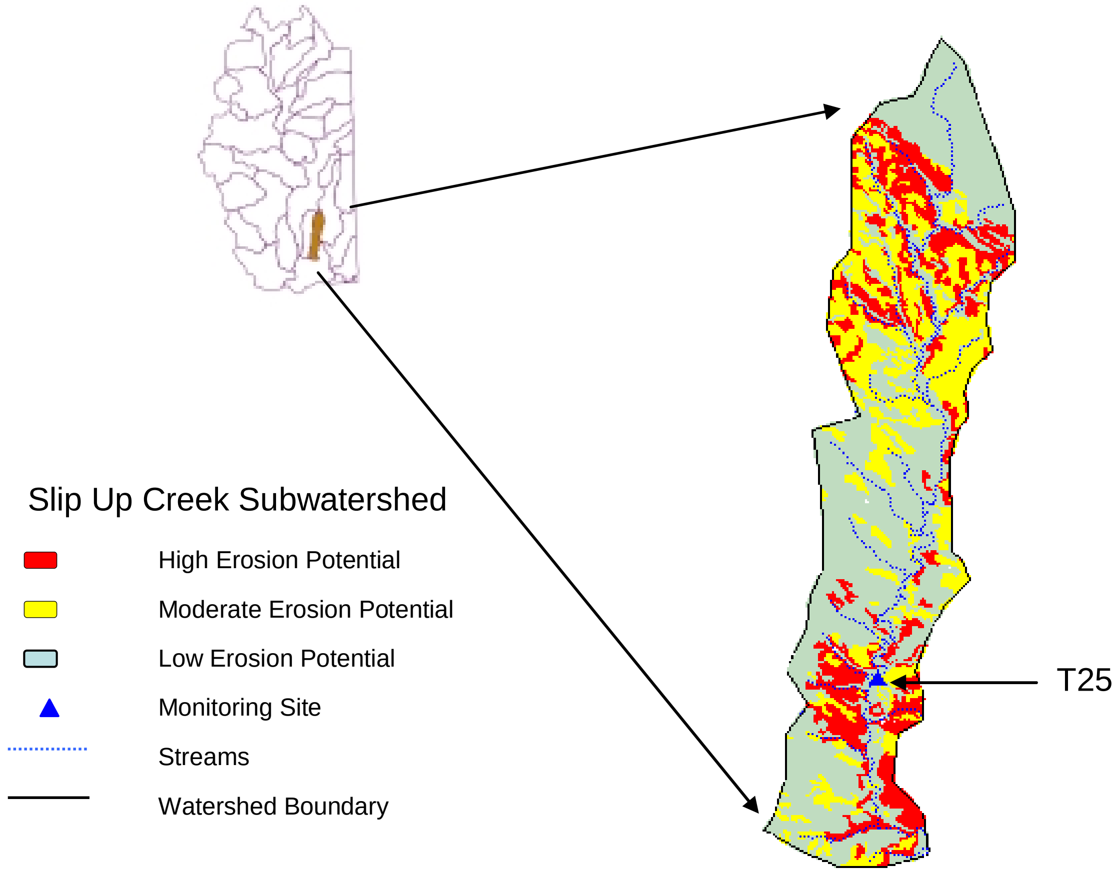


Figure 145. Slip-Up Creek Subwatershed Location Map

Slip-Up Creek Subwatershed Land Use

Land use in the watershed is predominantly agricultural (Figure 146). Approximately 69 percent of the area is cropland, such as corn and soybeans, and 29 percent is grassland and pastureland. There are 12 animal feeding operations located in the watershed, with 92 percent of the livestock being cattle (See Figure 147). There are no municipalities within this watershed.

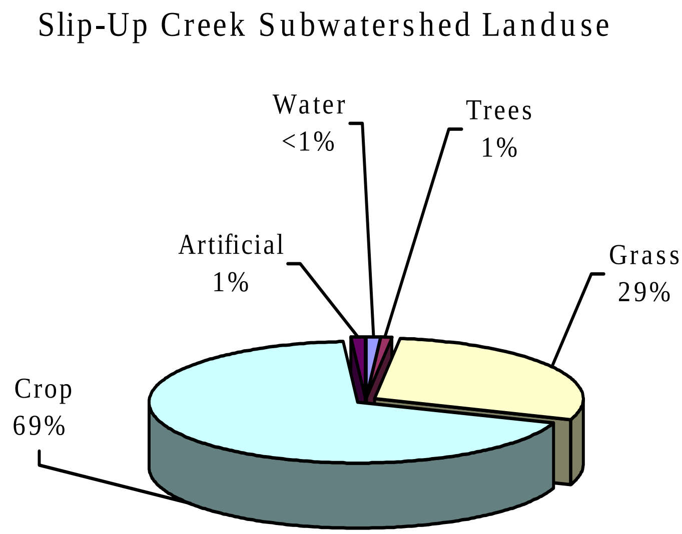


Figure 146. Slip-Up Creek Subwatershed Landuse

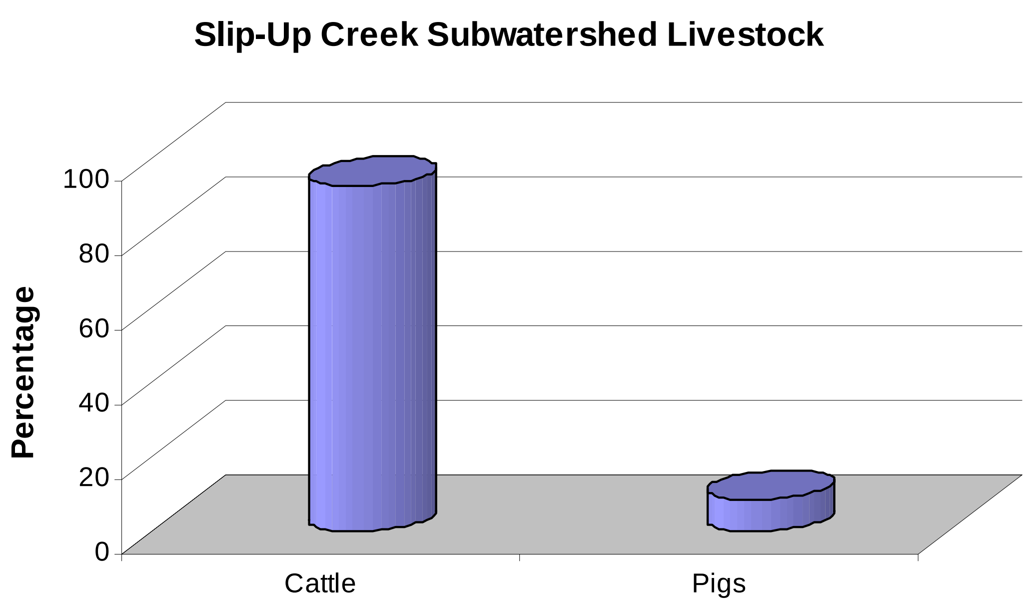


Figure 147. Slip-Up Creek Subwatershed Livestock

Water Quality Summary

The Slip-Up Creek subwatershed site (T25), located in the Western Cornbelt Plains, is meeting water quality criteria for beneficial uses (9) Fish and Wildlife Propagation, Recreation and Stock Watering and (10) Irrigation (refer to Table 6 for each sites beneficial use).

Although the numeric criteria for fecal coliform bacteria do not apply for this subwatershed, the following figures are for informational purposes. Fecal coliform bacteria ranged from 1,000-62,000 cfu/100mL (See Appendix DD). Based on average daily discharge and seasonal grab sample data, the monitored load as compared to a target load of 400 cfu/100mL was graphed into five hydrologic zones (See Figure 148). Figure 149 shows the grab samples taken during the study.

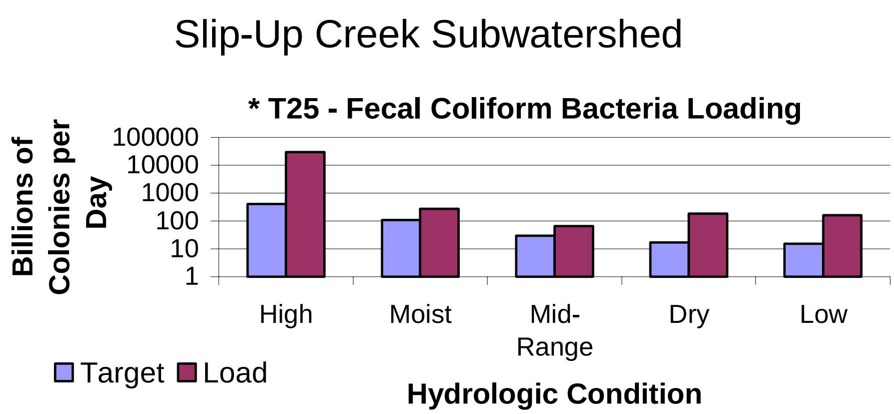


Figure 148. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Slip-Up Creek Subwatershed

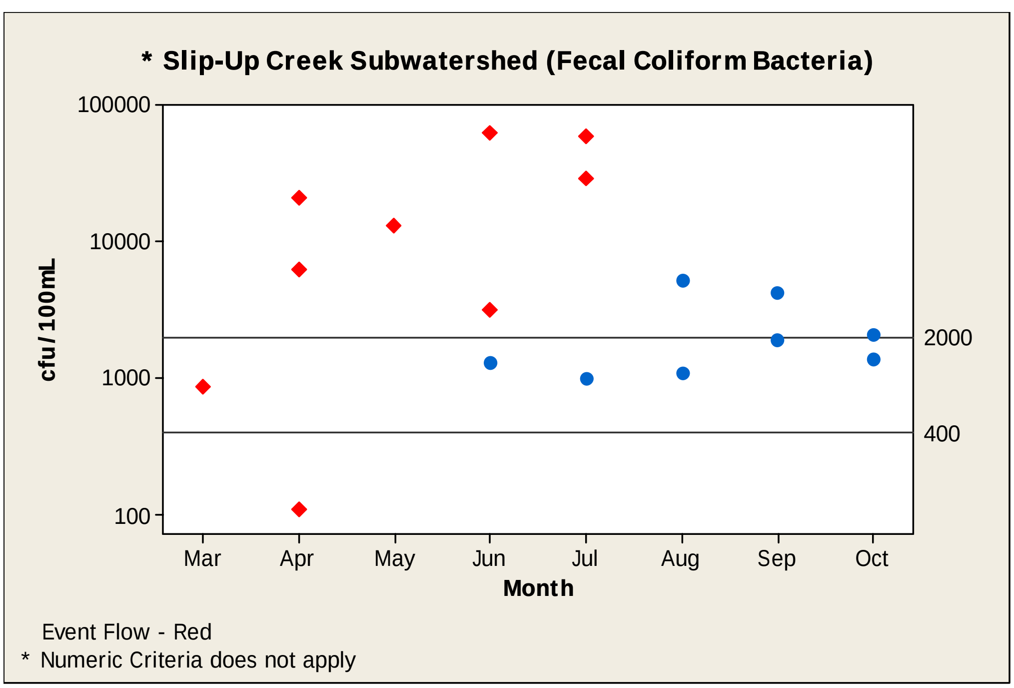


Figure 149. Scatterplot of Fecal Coliform Bacteria Grab Samples for Slip-Up Creek Subwatershed

Although the numeric criteria for TSS do not apply for this subwatershed, the following figures are for informational purposes. TSS ranged from 13-892 mg/L (See Appendix DD). Based on FLUX model results, Figure 150 shows the estimated TSS loadings for T25 as compared to a standard of 158 mg/L. Figure 151 shows the grab samples taken during the study.

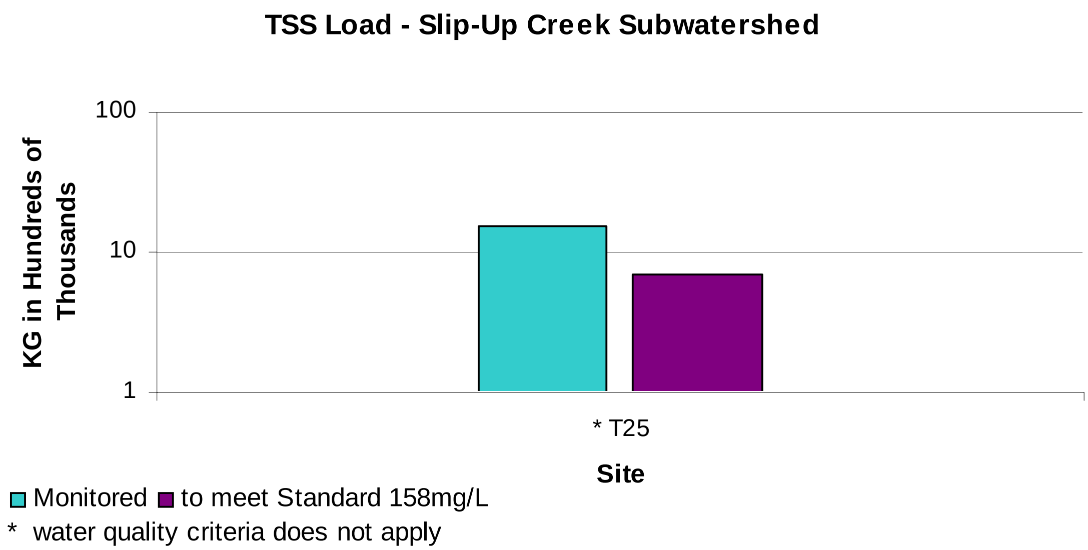


Figure 150. TSS in kg Monitored vs the Standard for the Slip-Up Creek Subwatershed

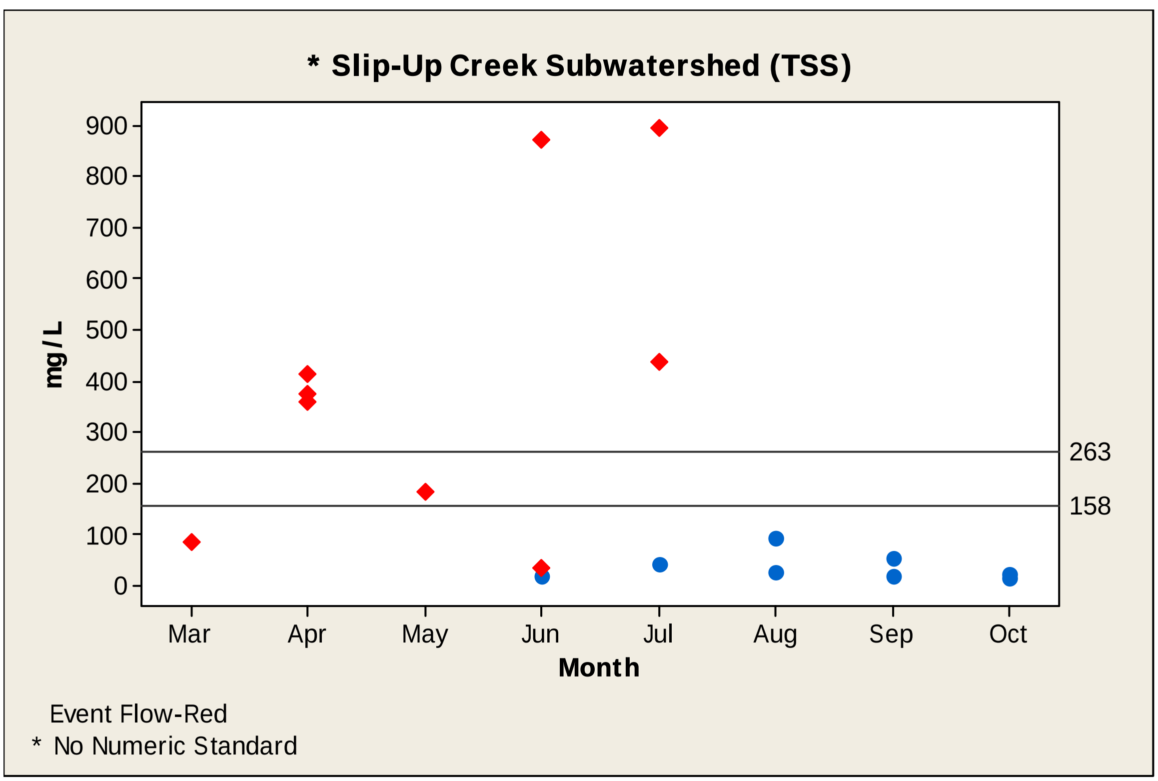


Figure 151. Scatterplot of TSS Grab Samples for the Slip-Up Creek Subwatershed

Additionally, a linear regression was completed to find the relationship between TSS and NTU, $R^2 = 0.6999$ (See Figure 152).

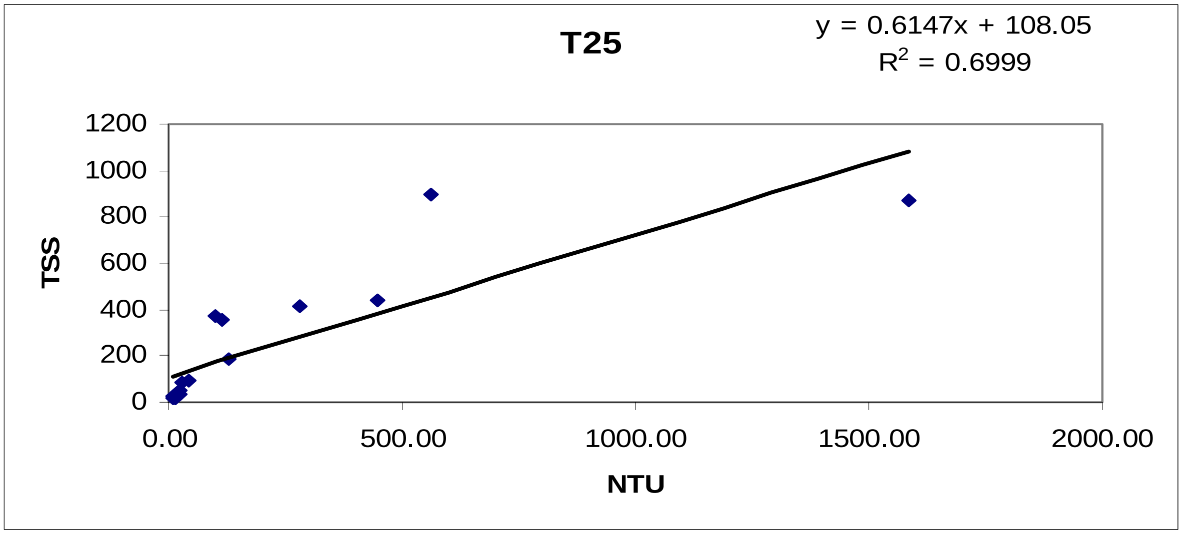


Figure 152. Comparison of TSS and Turbidity for the Slip-Up Creek Subwatershed

The Slip-Up Creek subwatershed total phosphorus summer mean was 0.61 mg/L, as compared to the ecoregion mean of 0.30 mg/L (Fandrei et al 1988). This is more than double the ecoregion mean, with possible sources from livestock and human waste, and commercial fertilizers.

Biological Data Summary

Fish, habitat, and macroinvertebrates were collected in the Slip-Up Creek Subwatershed. Score sheets for this site can be found in Appendix I for fishes, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for this site is severe.

The fish IBI score of 40 was low with no occurrences of sensitive species and a high percentage of tolerant species. The most abundant fish was the Bluntnose Minnow, with high numbers of Bigmouth Shiners and Creek Chubs. The physical habitat scored a 65 due to poor bed composition and minimal physical complexity. Macroinvertebrates scored a 62, with an HBI of 7.1, a low percentage of EPT, and a high number of tolerant organisms.

Source Linkage and Conclusion

As stated earlier, this subwatershed is meeting its assigned water quality criteria. There are no standards set for fecal coliform bacteria or TSS.

Skunk Creek Subwatershed

This map (Figure 153) shows the area and location designated as the Skunk Creek Subwatershed and the potential for erosion.

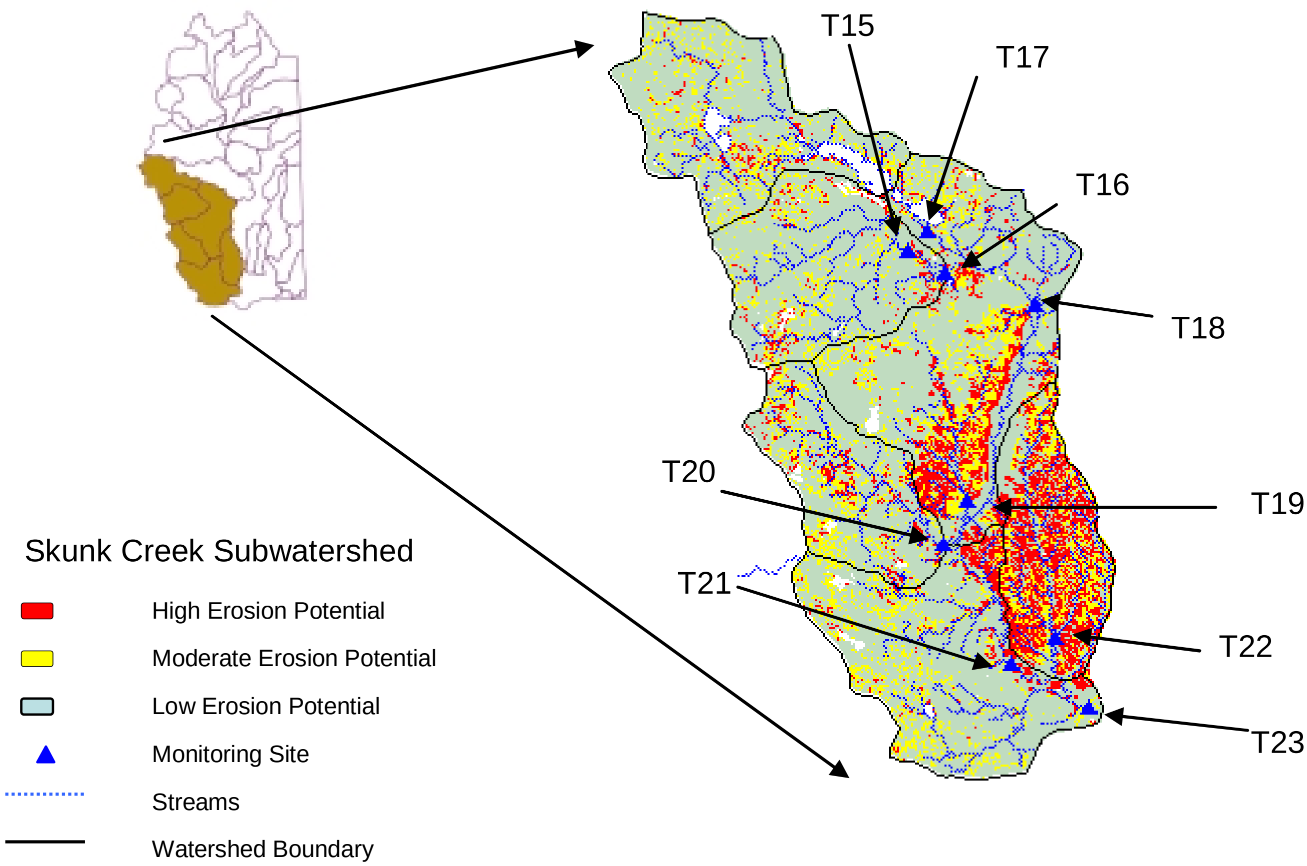


Figure 153. Skunk Creek Subwatershed Location Map

Skunk Creek Sub-Watershed Land Use

Land use in the watershed is predominantly agricultural (See Figure 154). Approximately 65 percent of the area is cropland, such as corn and soybeans, and 29 percent is grassland and pastureland. There are a total of 213 animal feeding operations, excluding feedlots above T17, in this subwatershed, with 66 percent of the livestock being cattle (See Figure 155). There are 11 NPDES permitted facilities (See Table 30 and 31).

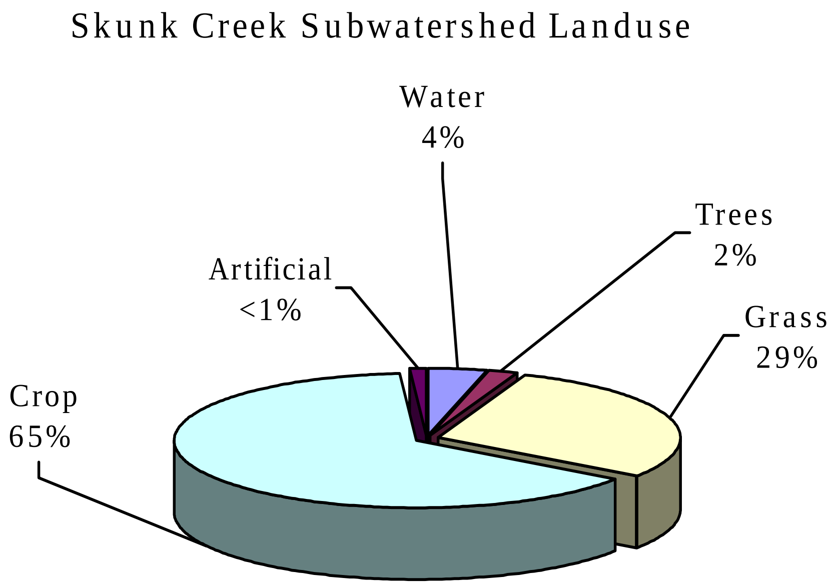


Figure 154. Skunk Creek Subwatershed Landuse

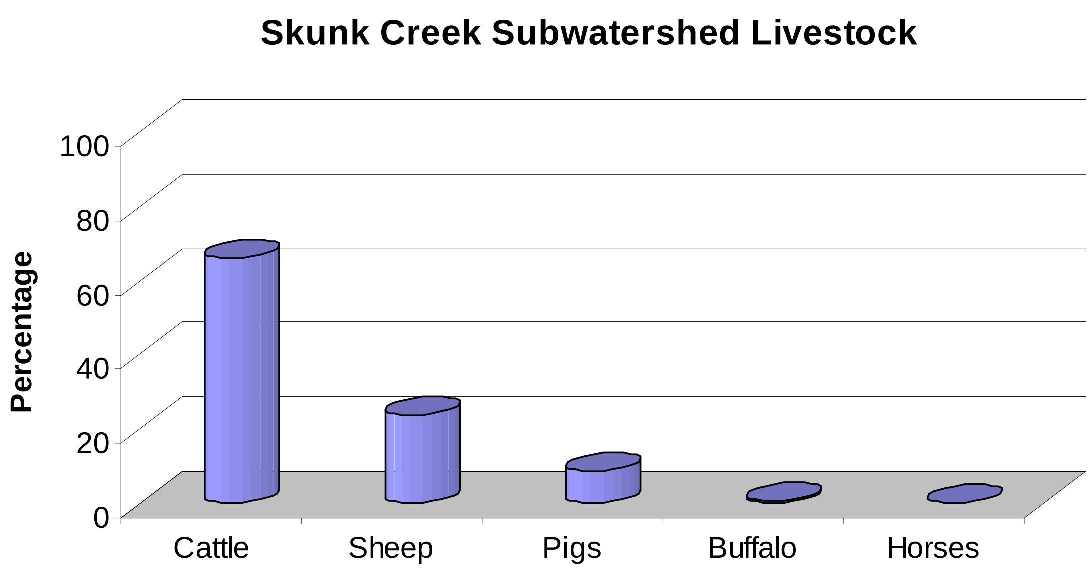


Figure 155. Skunk Creek Subwatershed Livestock

Water Quality Summary

The Skunk Creek subwatershed (T15-T23), located in the Western Cornbelt Plains, meets water quality criteria except for fecal coliform bacteria. Beneficial uses listed for the sites in this watershed are (refer to Table 6 for each sites beneficial use):

(6) Warmwater Marginal Fish Life Propagation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

The subwatershed meets the water quality criteria for beneficial uses (6), (9), and (10). However, sites T18 and T23 are not meeting the fecal coliform bacteria (2000 cfu/100mL) water quality criteria for beneficial use (8) Limited Contact Recreation (See Figure 156). Fecal coliform bacteria ranged from 40-210,000 cfu/100mL (See Appendix DD). Based on average daily discharge and seasonal grab sample data, the monitored load as compared to a target load of 2000 cfu/100mL was graphed into five hydrologic zones (See Figure 157). Figure 158 shows the grab samples taken during the study.

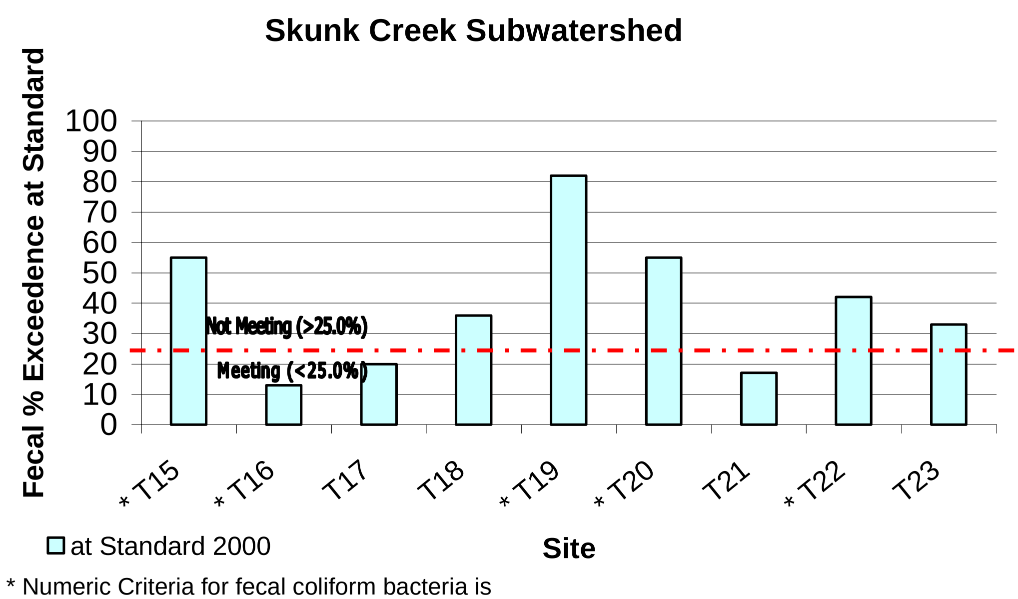
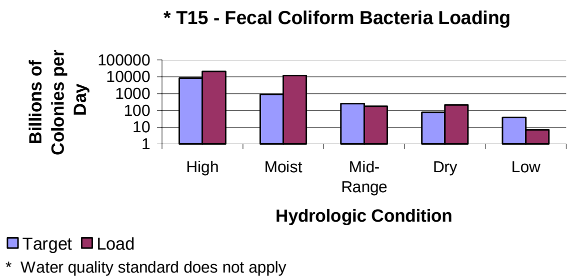
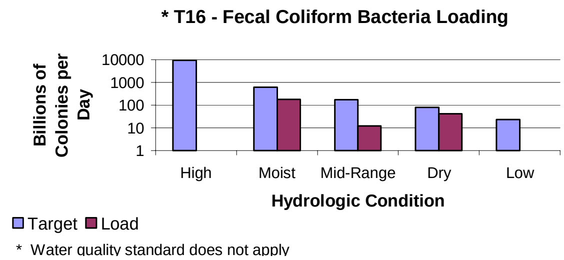
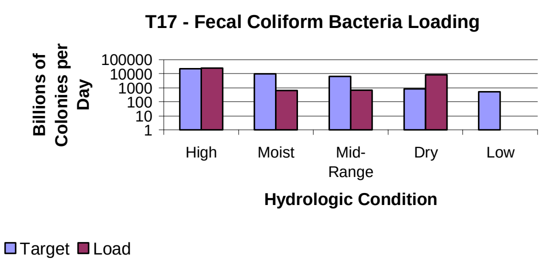


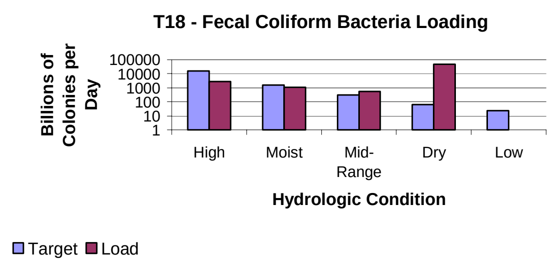
Figure 156. Fecal Coliform Bacteria Percent Exceedence at standard 2000 cfu/100mL in the Skunk Creek Subwatershed

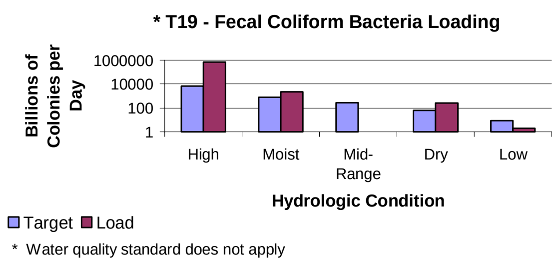
Skunk Creek Subwatershed

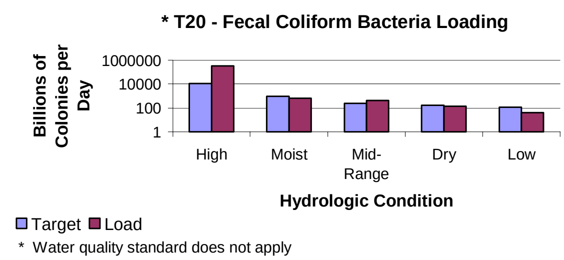


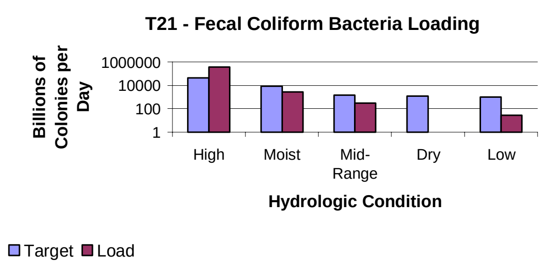


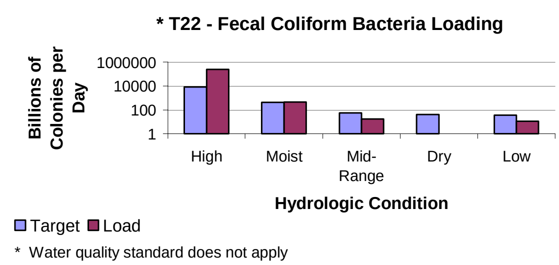












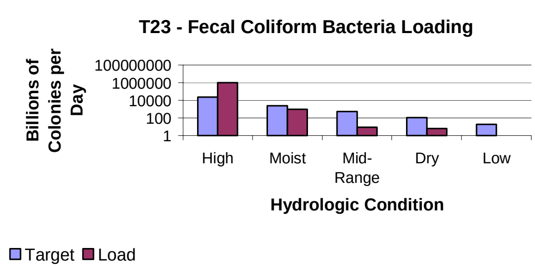


Figure 157. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Skunk Creek Subwatershed

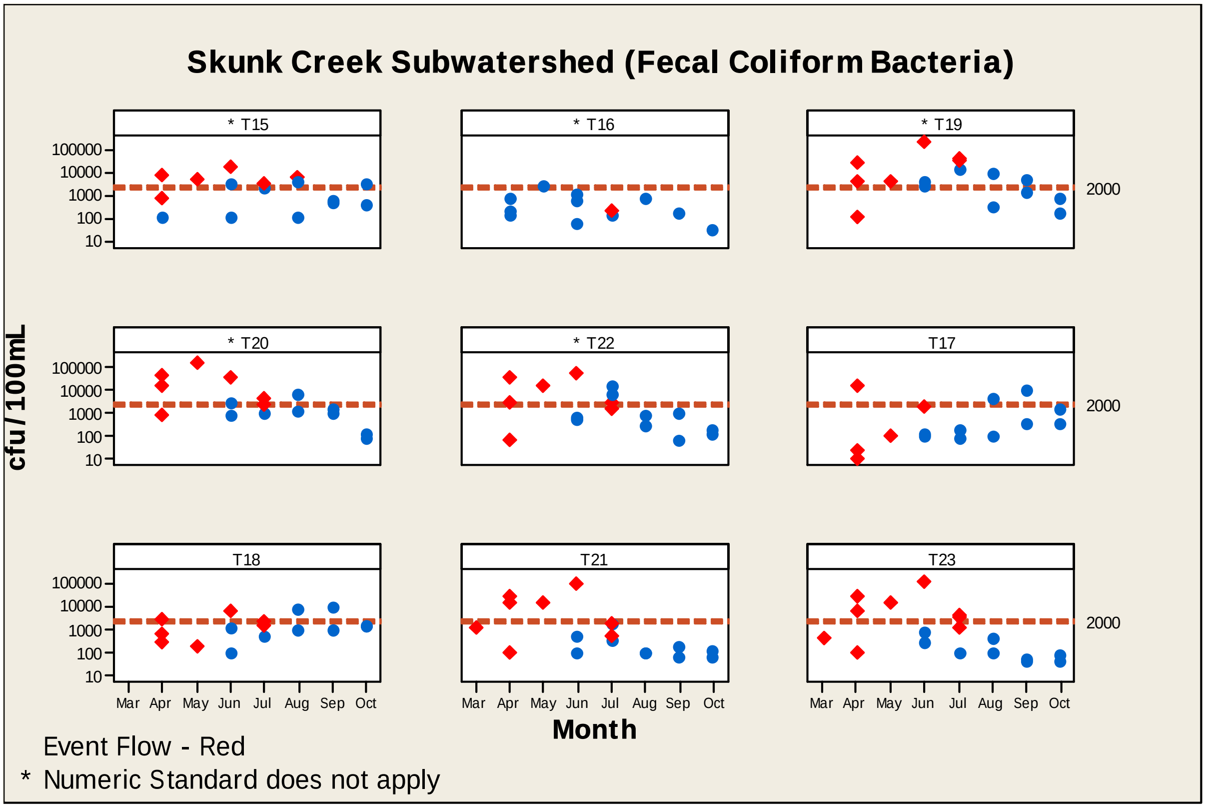


Figure 158. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Skunk Creek Subwatershed

Although the Skunk Creek Subwatershed is meeting the water quality standards for TSS, Figure 159 is for informational purposes. TSS ranged from 2-784 mg/L, with six percent or less violations for those locations where the numeric standard applies (See Appendix DD). Based on FLUX model results, Figure 160 shows the estimated TSS loadings for sites T15-T23 as compared to the standard of 263 mg/L. A scatterplot of grab samples taken during the study are shown in Figure 161.

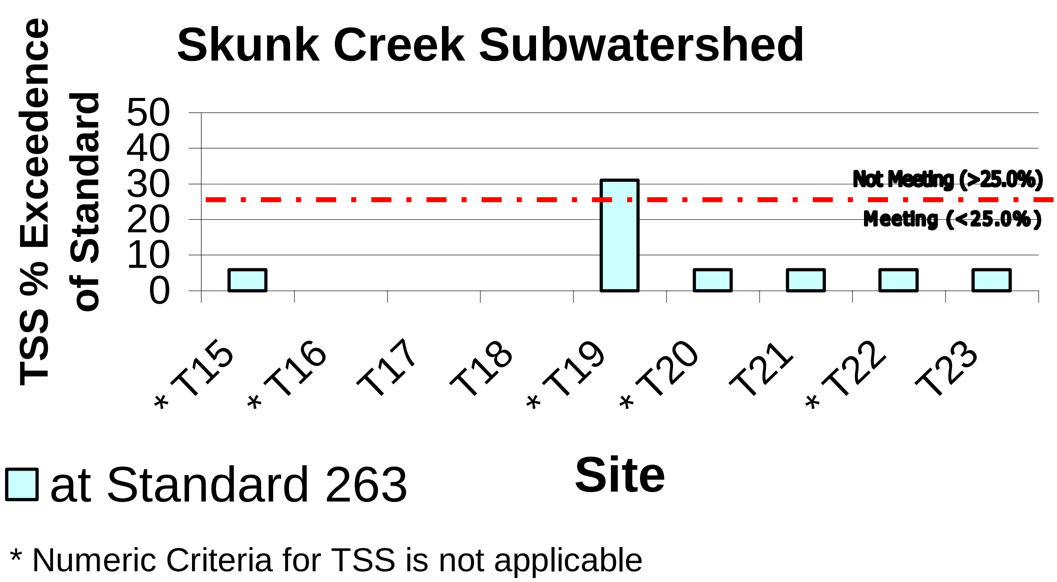


Figure 159. TSS Percent Exceedence at standard 263 mg/L in the Skunk Creek Subwatershed

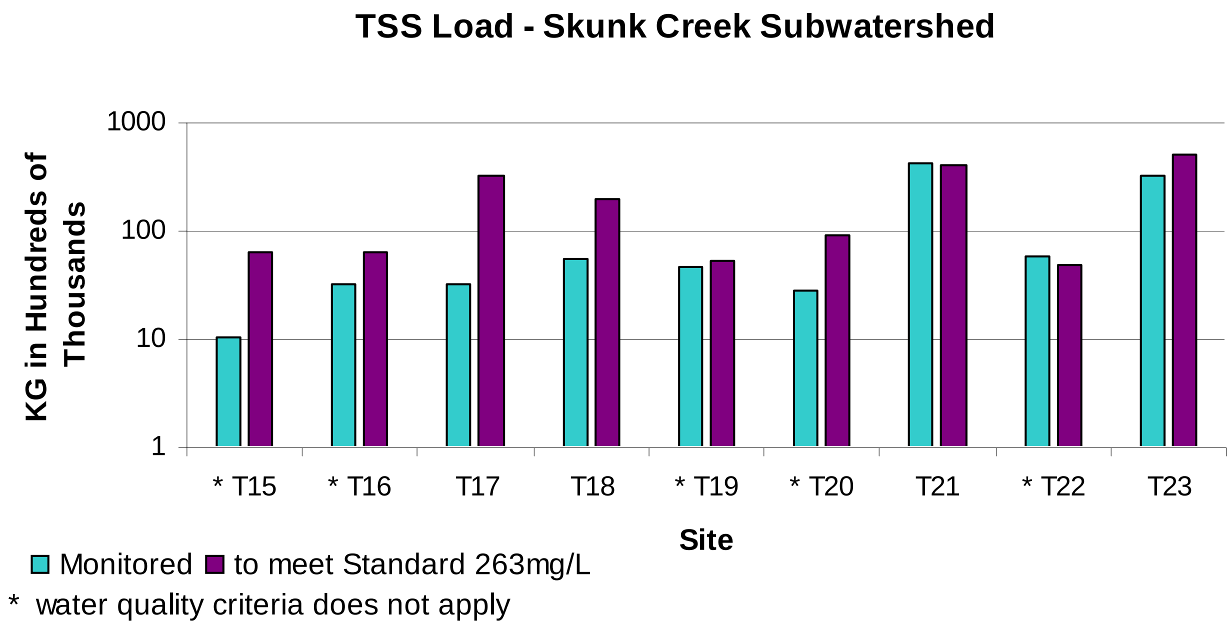


Figure 160. TSS in kg Monitored vs the Standard for the Skunk Creek Subwatershed

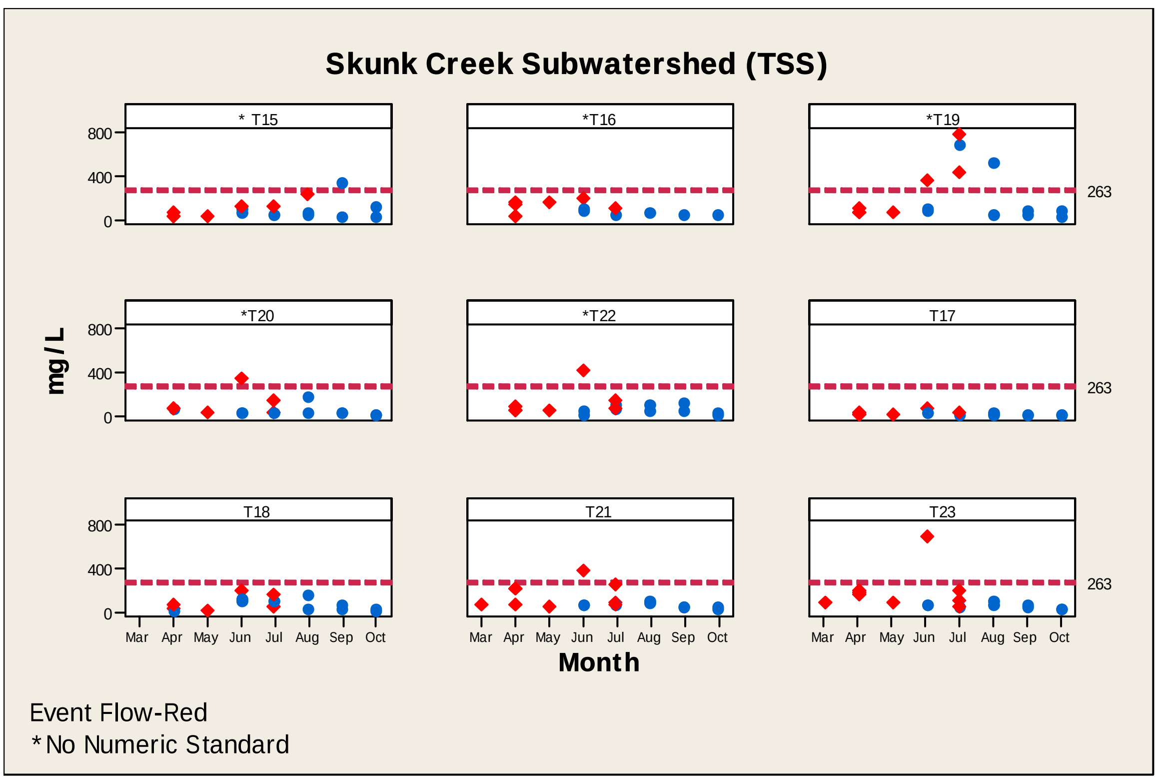


Figure 161. Scatterplot of TSS Grab Samples for the Skunk Creek Subwatershed

Additionally, linear regressions were completed for each monitoring location to find the relationship between TSS and NTU (See Figure 162). R^2 ranged from 0.4757 at Site T21 to 0.9724 at Site T19.

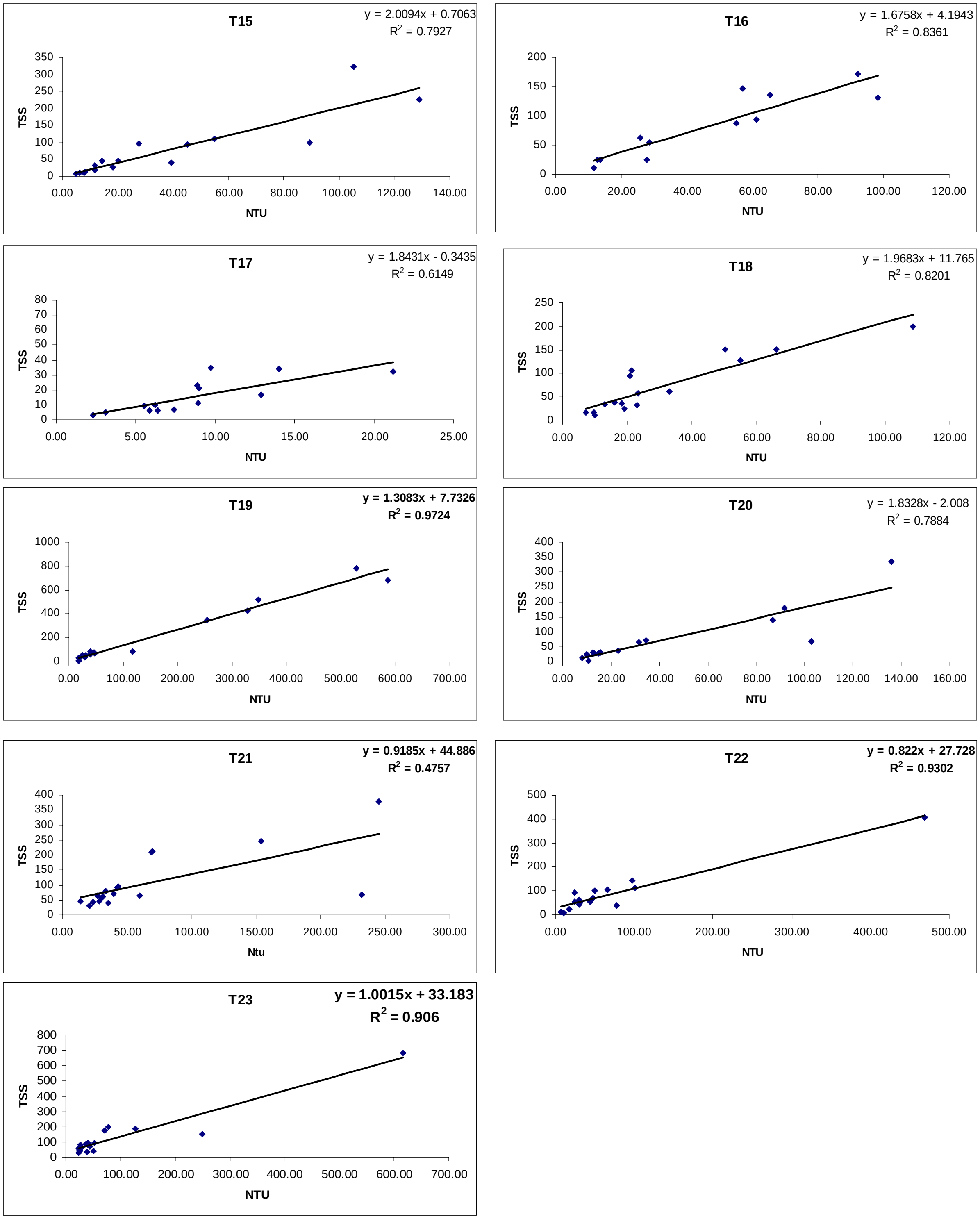


Figure 162. Comparison of TSS and Turbidity for the Skunk Creek Subwatershed

The following table (Table 46) summarizes the ranges of fecal coliform bacteria (cfu/100mL), ranges of TSS (mg/L), and the percent exceedences. It also shows the summer mean of total phosphorus (mg/L).

Table 46. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 for the Skunk Creek Subwatershed

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
T15	99-16000	--	8-324	--	0.32
T16	50-2200	--	12-172	--	0.37
T17	80-9800	20	3-67	0	0.19
T18	100-9100	36	11-200	0	0.30
T19	300-210000	--	8-784	--	0.75
T20	800-160000	--	2-334	--	0.51
T21	60-106000	17	32-378	6	0.55
T22	70-60000	--	8-408	--	0.45
T23	40-134000	33	30-684	6	0.38

Based on the monitoring and modeling results Skunk Creek Subwatershed accounts for two percent of the total TSS loading to the Big Sioux River (R13) (See Figure 62). A breakdown of this two percent is shown below, in Figure 163. The analysis for Figure 163 used the sampling months of Jul 2000 to Oct 2000 and Mar 2001 to Oct 2001. Since data was available for the months of Mar-Apr 2001, it was included in the analysis because it was more reflective of spring runoff conditions. See Appendix MM for pollutant load summary calculations.

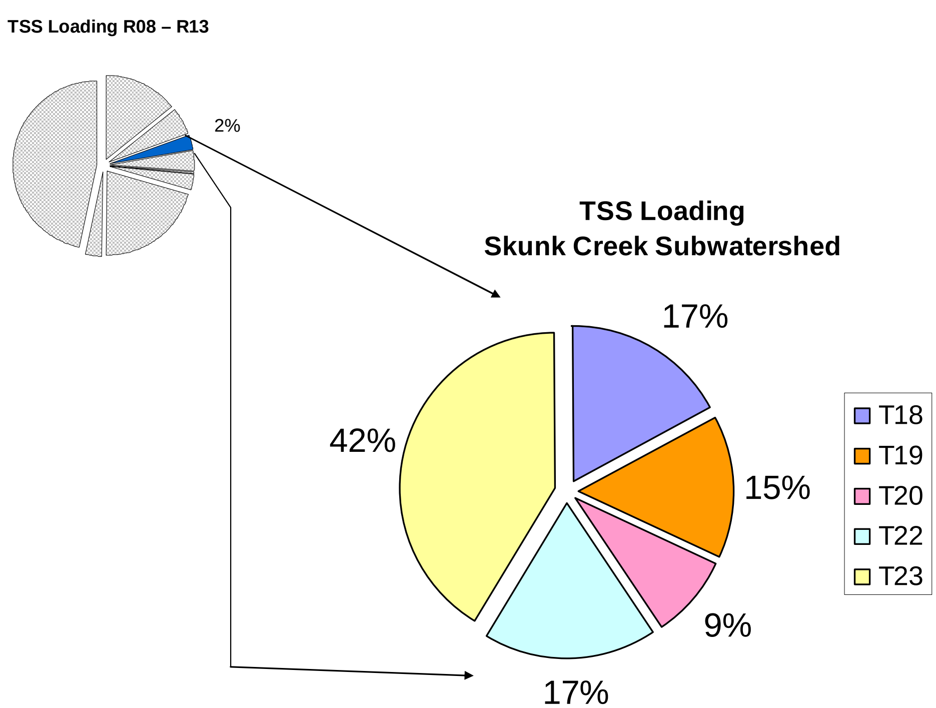


Figure 163. Percent Contributions of TSS Loading of the Skunk Creek Subwatershed

The sediment loading above T23, minus T18, T19, T20 and T22, is 42 percent, which is 0.84 percent of the total loading at R13. This comprises an area of approximately 114,081 acres which yielded 0.13 tons of sediment per acre for the months that were monitored.

The sediment loading above T22 is 17 percent, which is 0.34 percent of the load at R13. This comprises an area of approximately 30,682 acres which yielded 0.21 tons of sediment per acre for the months that were monitored.

The sediment loading above T18 is 17 percent, which is 0.34 percent of the load at R13. This comprises an area of approximately 143,264 acres which yielded 0.04 tons of sediment per acre for the months that were monitored.

The sediment loading above T19 is 15 percent, which is 0.30 percent of the load at R13. This comprises an area of approximately 40,549 acres which yielded 0.13 tons of sediment per acre for the months that were monitored.

The sediment loading above T20 is 9 percent, which 0.18 percent of the load at R13. This comprises an area of approximately 43,236 acres which yielded 0.07 tons of sediment per acre for the months that were monitored.

The summer mean concentrations for total phosphorus of sites T16, T19, T20, T21, T22, and T23 are greater than the ecoregion mean of 0.30 mg/L (Fandrei et al 1988). These higher numbers can be attributed to sources such as livestock and human waste, and commercial fertilizers (See Table 46).

Biological and Physical Habitat Summary

All sites were surveyed for fish, habitat, and macroinvertebrates in the Skunk Creek Subwatershed, with the exception of T16 where the macroinvertebrates were not sampled due to dry conditions. Score sheets for each of these sites can be found in Appendix I for fishes, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for these sites are listed in Table 47 and range from minimal to severe.

Overall, Site T23 was in the best biological condition with minimal suggested impairment. The biological data consisted of a very high percentage of EPT, a very low percentage of tolerant macroinvertebrate organisms, and an HBI of 4.97. More than 1,900 Red Shiners were found, with high abundances of Sand Shiners and Emerald Shiners. Site T23 scored high in all habitat areas except for an absence of overhanging vegetation.

Sites T20 and T21 suggest a minimal to moderate impairment, scoring higher in macroinvertebrates than with the fish or habitat. There was a low percentage of tolerant macroinvertebrate organisms and a high percentage of EPT.

Site T15 suggests a moderate to severe impairment. Macroinvertebrate IBI was 67, with an HBI of 6.8, and a very low percentage of EPT. Only six species of fish were found at this site including Black Bullhead, White Suckers, and high numbers of Sand Shiners. Habitat lacked physical complexity, with poor bed composition, and an absence of overhanging vegetation.

Biological data collected from the remaining sites, T16, T17, T18, T19, and T22 suggest severe impairment. The habitat had poor bed composition, very little overhanging vegetation, frequent animal vegetation use, and lacked physical complexity. The percentage of EPT macroinvertebrates was very poor. Some highly tolerant organisms were found, especially at T17 and T18. HBI's ranged from 6.4 to 8.4. Site T16 had a fish IBI of 24 consisting of 650 Black Bullheads, numerous Common Carp, and Yellow Perch. Several lentic species, including Black Crappie, Northern Pike, Bluegill, White Bass, and Yellow Perch were found at Site T17 which is a lake outlet. Sites T18, T19, and T22 rated fair for fish IBI.

Table 47. Final Index Values for Bugs, Fish, and Habitat for the Skunk Creek Subwatershed

Site	Macroinverts	Fish	Habitat	Suggested Impairment
T15	67	49	50	Moderate to Severe
T16	NA	24	62	Severe
T17	51	36	46	Severe
T18	54	56	40	Severe
T19	62	54	31	Severe
T20	71	60	67	Minimal to Moderate
T21	79	69	61	Minimal to Moderate
T22	64	52	39	Severe
T23	73	80	75	Minimal

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria (Table 48) and TSS (Table 49) would need the following reductions at each site:

Table 48. Percent Fecal Coliform Bacteria Reduction and Possible Sources for the Skunk Creek Subwatershed

Site	Numeric Criteria	Fecal % Reduction * (Flow)	Event vs Base Flow	Possible Sources
T15	--	--	NA	NA
T16	--	--	NA	NA
T17	2000	20 (H), 91 (D)	Base Flow	instream livestock, poor riparian areas, septic failure
T18	2000	51 (MR), 100 (D)	Both	failing septic systems, instream livestock, inadequate manure application, feedlot runoff, and poor riparian areas
T19	--	--	NA	NA
T20	--	--	NA	NA
T21	2000	89 (H)	Event	failing septic systems, and poor riparian areas
T22	--	--	NA	NA
T23	2000	98 (H)	Event	failing septic systems, and poor riparian areas

-- numeric standard not applicable
* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%) MR=Mid-Range Flows (40-60%)
D=Dry Conditions (60-90%) L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, there are 68 feedlots within this subwatershed with a ranking ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the low flows concentration. The City of Hartford was the only identified point source that discharged during the sampling period. Their contribution was calculated to be insignificant, although it was noted that they had some very high daily maximums. Reductions should focus on non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas section).

Table 49. Percent TSS Reduction and Possible Sources for the Skunk Creek Subwatershed

Site	Numeric Criteria	TSS % Reduction	Possible Sources
T15	--	--	NA
T16	--	--	NA
T17	263	0	NA
T18	263	0	NA
T19	--	--	NA
T20	--	--	NA
T21	263	10	cropland erosion, streambank erosion, construction erosion
T22	--	--	NA
T23	263	0	NA

-- numeric standard not applicable

Based on current water quality criteria, a TSS reduction is needed at T21. The cities of Colton, Crooks, and Hartford are the only identified point source contributors to TSS; however, their total contribution is less than one percent of the combined (T19, T21, and T22) TSS load in Skunk Creek subwatershed (See Table 30).

Split Rock Creek Subwatershed

Figure 164 shows the area and location designated as the Split Rock Creek Subwatershed and the potential for erosion.

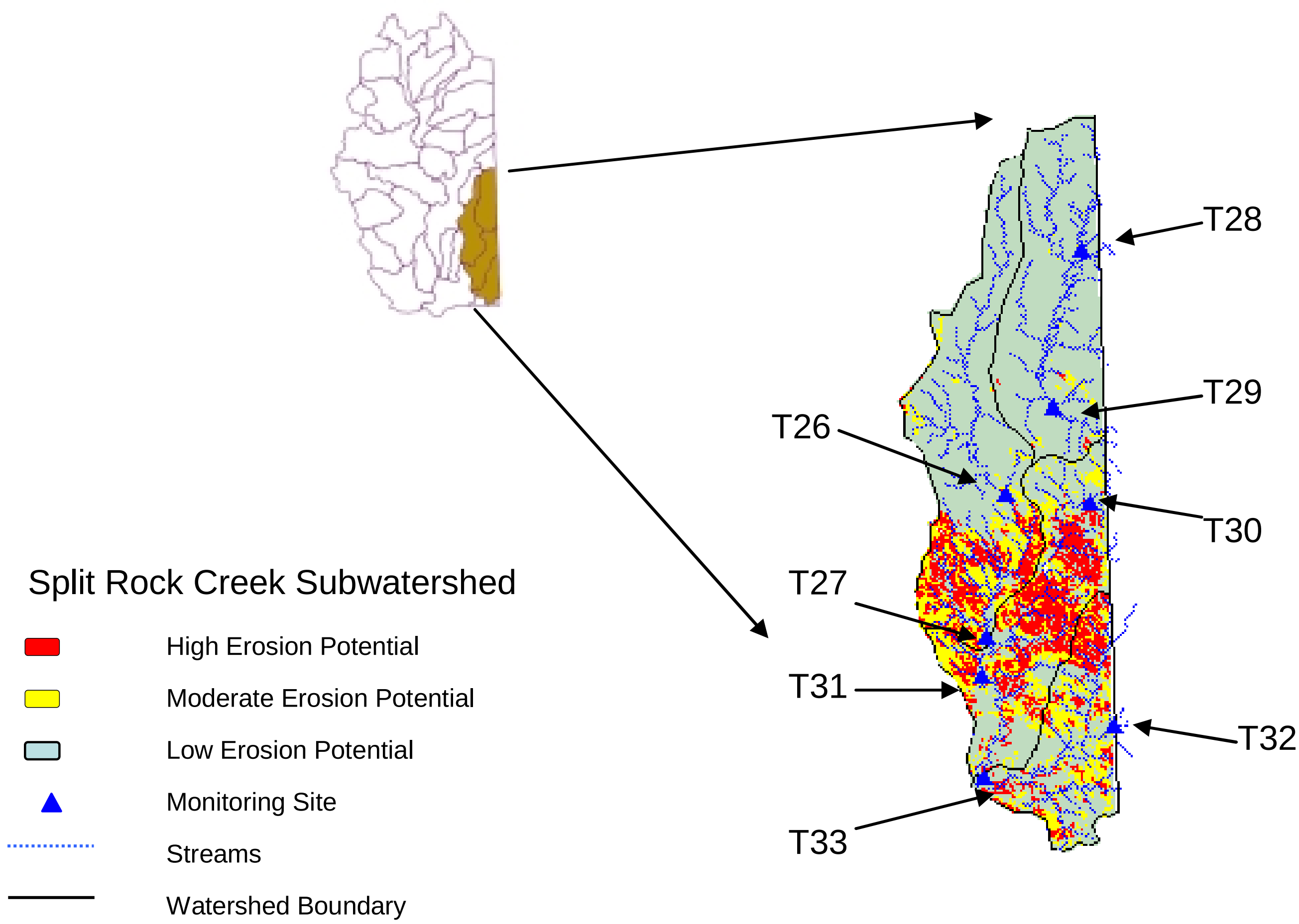


Figure 164. Split Rock Creek Subwatershed Location Map

Split Rock Creek Sub-Watershed Land Use

Approximately 40 percent of this subwatershed lies within the South Dakota borders, while the remaining area lies within Minnesota. Land use in the South Dakota portion of the sub-watershed that is predominantly agricultural (Figure 165). Approximately 76 percent of the area is cropland, such as corn and soybeans, and 23 percent is grassland and pastureland. See Appendix NN for a more detailed land use breakdown by site. There are a total of 124 feedlots in the South Dakota portion of subwatershed, with 84 percent of the livestock being cattle (See Figure 166). There are four NPDES permitted facilities in South Dakota (See Table 30 and 31), and there are four known municipalities in the Minnesota area of this subwatershed.

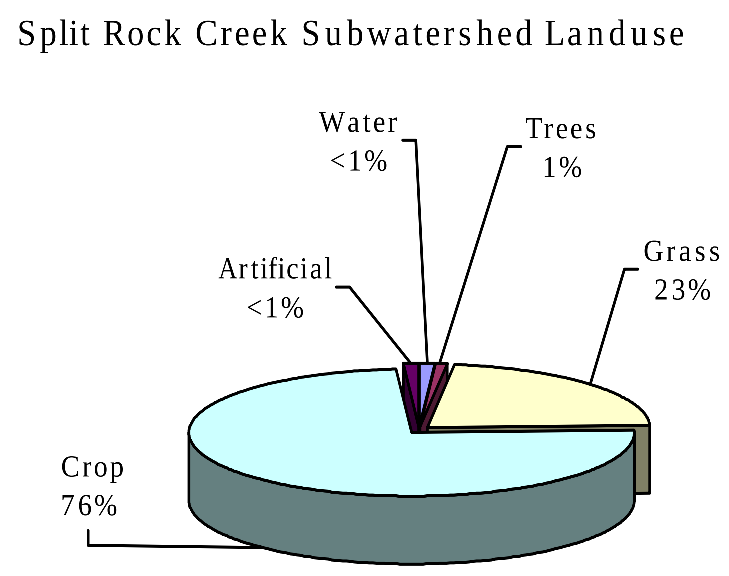


Figure 165. Split Rock Creek Subwatershed Landuse

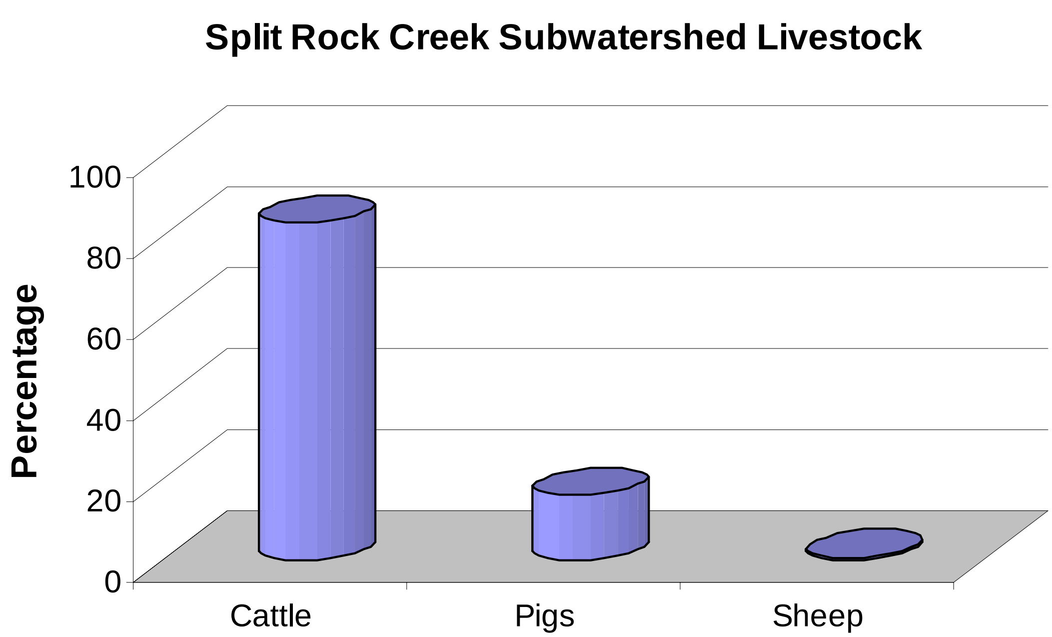


Figure 166. Split Rock Creek Subwatershed Livestock

Water Quality Summary

The Split Rock Creek subwatershed (T26-T33), located in the Western Cornbelt Plains, is meeting the water quality criteria, except for TSS and fecal coliform bacteria. Beneficial uses listed for the sites in this watershed are (refer to Table 6 for each sites beneficial use):

(5) Warmwater Semi-permanent Fish Life Propagation
(6) Warmwater Marginal Fish Life Propagation
(7) Immersion Recreation
(8) Limited Contact Recreation
(9) Fish and Wildlife Propagation, Recreation and Stock Watering
(10) Irrigation

All sites are assigned beneficial use (9) and (10) and are meeting the water quality criteria. Beneficial use (5) applies to sites T28, T29, T30, and T31, which are meeting water quality criteria for TSS (158 mg/L). Beneficial use (6) applies to sites T32 and T33 which are not meeting water quality criteria for TSS (263 mg/L) (See Figure 167). TSS ranged from 3-1,580 mg/L, with 29 percent or less violations for those locations where the numeric standard applies (See Appendix DD). Based on FLUX model results, Figure 168 shows the estimated TSS loadings for sites T26-T33 as compared to the standard of either 158 mg/L or 263 mg/L. A scatterplot of grab samples taken during the study are shown in Figure 169.

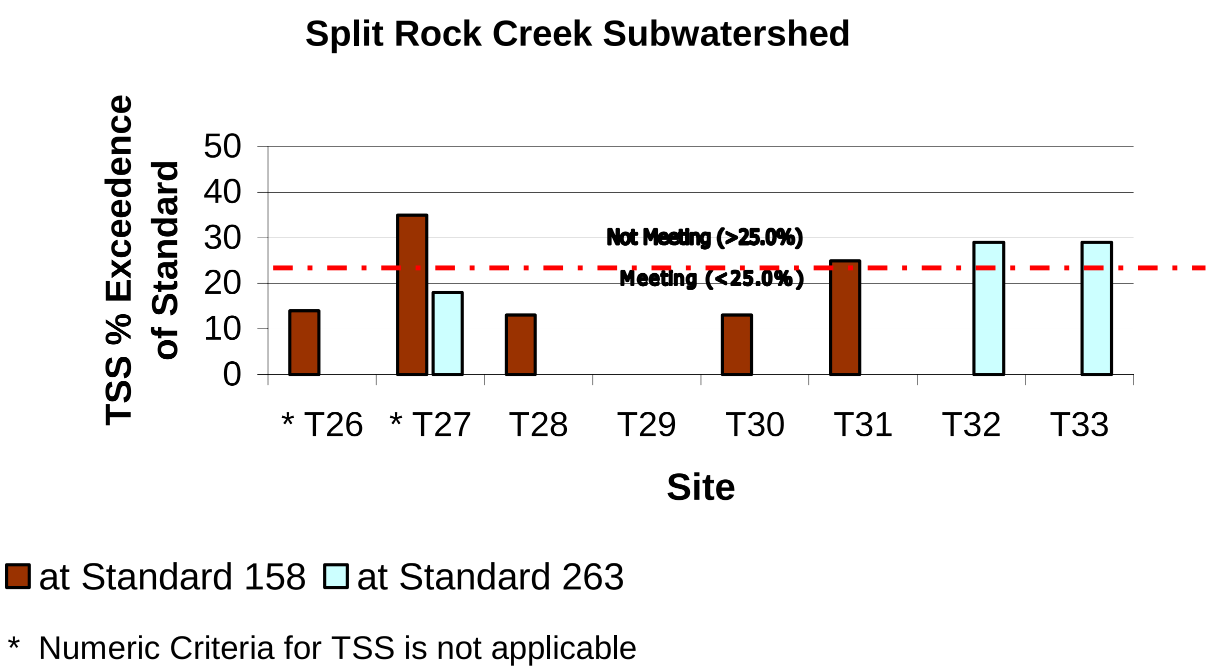


Figure 167. TSS Percent Exceedence of at Standard 158 mg/L (T28-T31) and at Standard 263 mg/L (T32-T33) in the Split Rock Creek Subwatershed

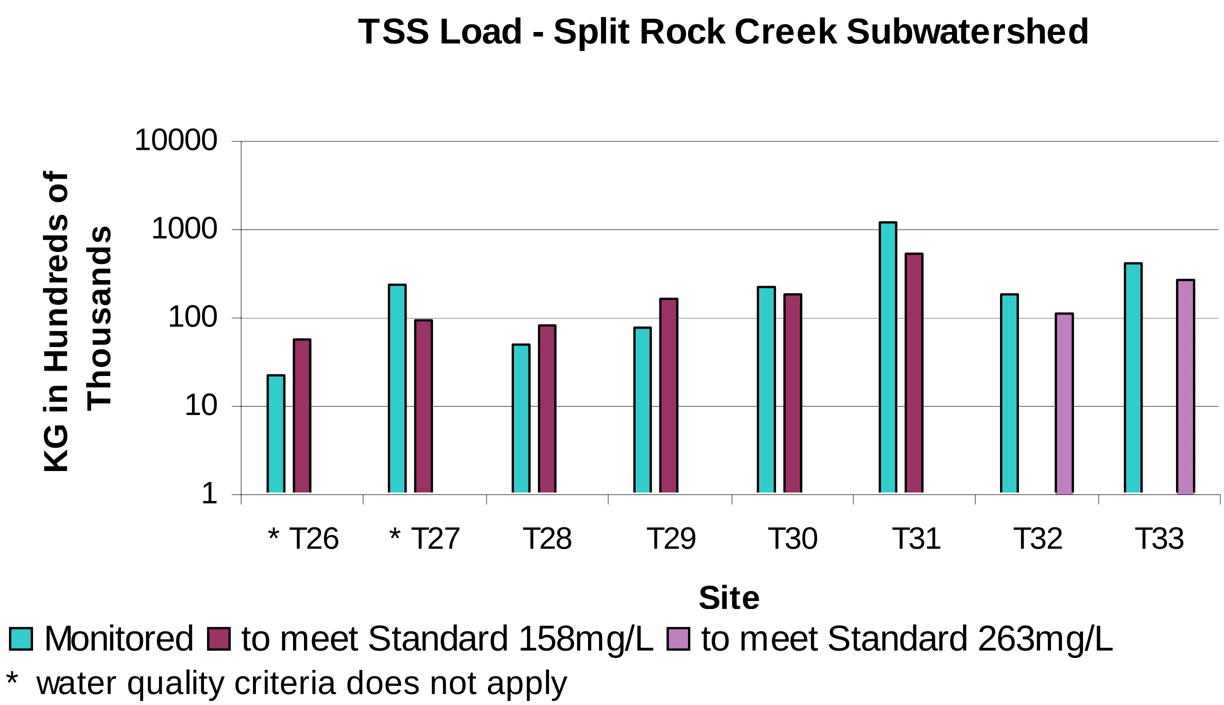


Figure 168. TSS in kg Monitored vs the Standard for the Split Rock Creek Subwatershed

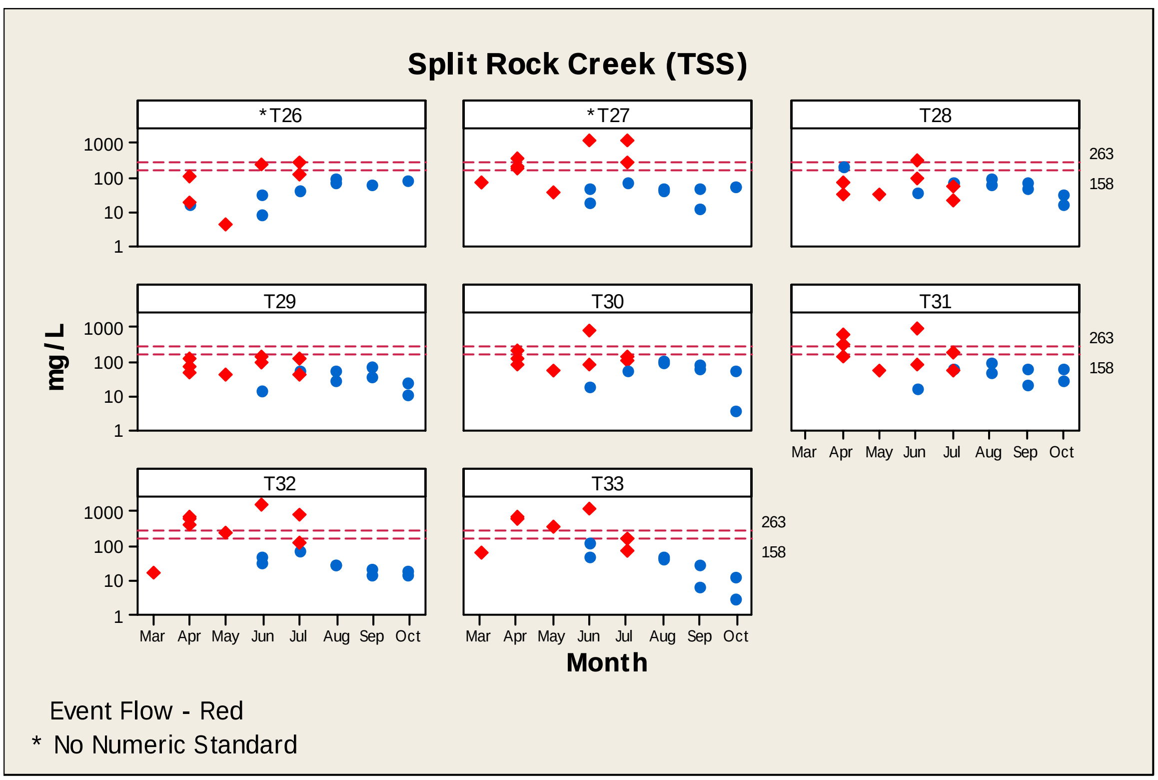


Figure 169. Scatterplot of TSS Grab Samples for the Split Rock Creek Subwatershed

Additionally, linear regressions were completed for each monitoring location to find the relationship between TSS and NTU (See Figure 170). R^2 ranged from 0.6537 at Site T26 to 0.9856 at Site T30.

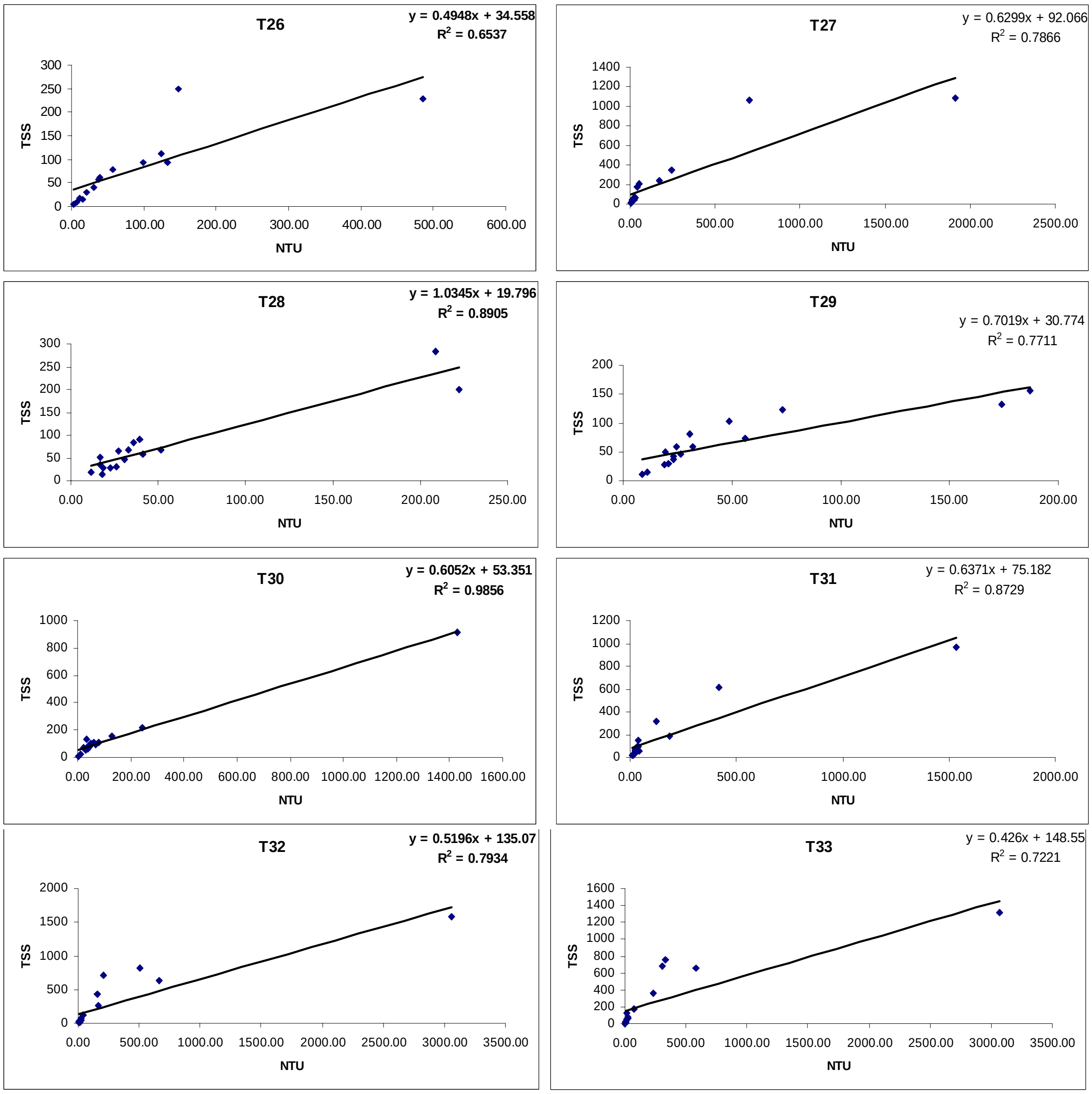
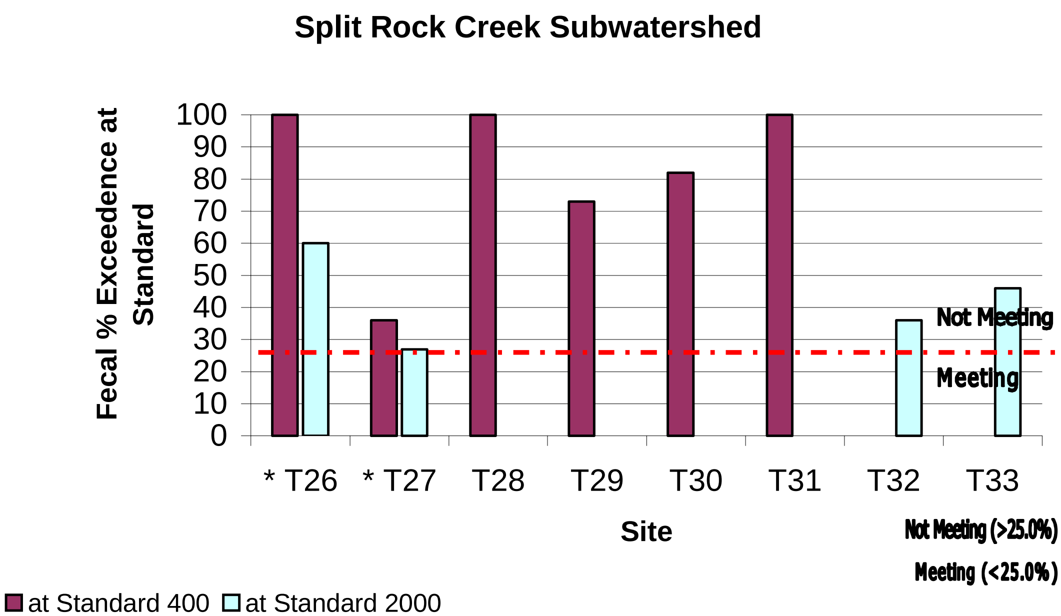


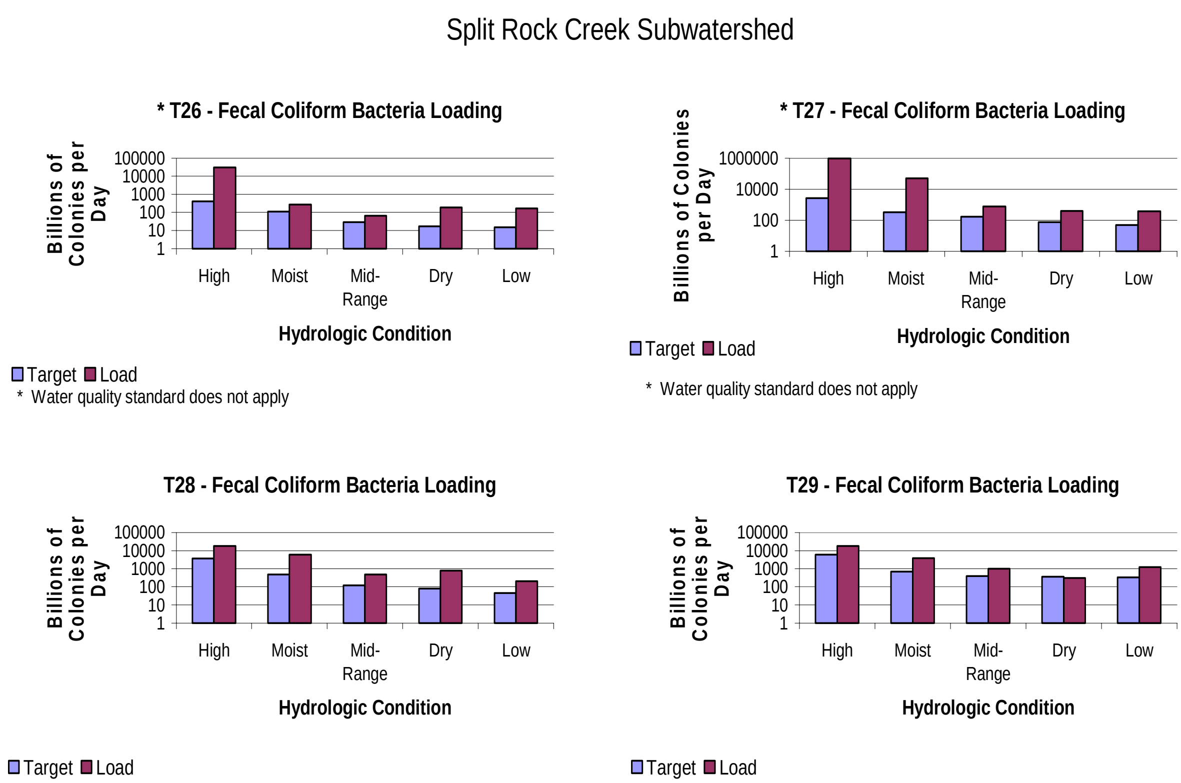
Figure 170. Comparison of TSS and Turbidity for the Split Rock Creek Subwatershed

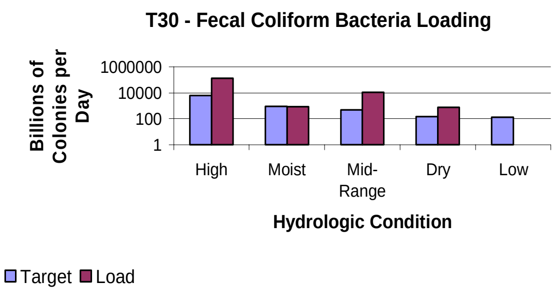
Beneficial use (7) applies to sites T28, T29, T30, and T31, which are not meeting water quality criteria for fecal coliform bacteria (400 cfu/100mL). Beneficial use (8) applies to sites T28-T33, but beneficial use (7) supercedes (8) for sites T28-T31. Sites T32 and T33 are not meeting water quality standards for fecal coliform bacteria (2000 cfu/100mL) for beneficial use (8) (See Figure 171). Fecal coliform bacteria ranged from 60-172,000 cfu/100mL (See Appendix DD). Based on average daily discharge and seasonal grab sample data, the monitored load as compared to a target load of either 400 cfu/100mL or 2000 cfu/100mL was graphed into five hydrologic zones (See Figure 172). Figure 173 shows the grab samples taken during the study.

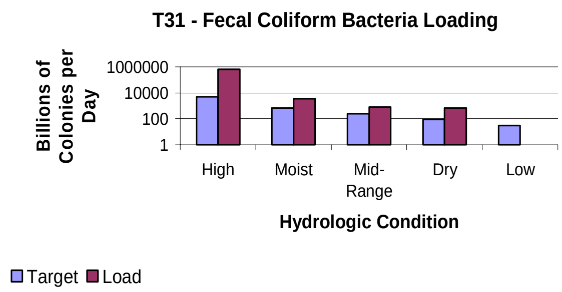


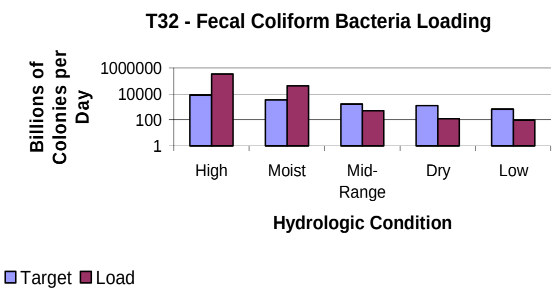
*   Numeric Criteria for fecal coliform bacteria is not applicable

Figure 171. Fecal Coliform Bacteria Percent Exceedence for Standard 400 cfu/100mL (T28-T31) and Standard 2000 cfu/100mL (T32-T33) in the Split Rock Creek Subwatershed









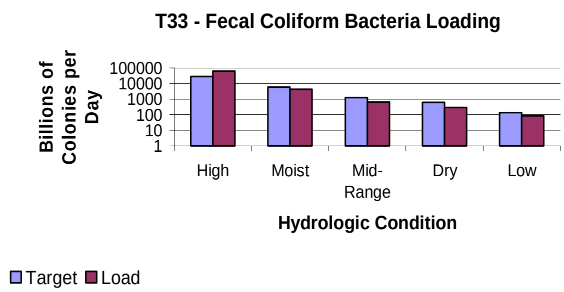


Figure 172. Load vs Target of Fecal Coliform Bacteria in Billions of Colonies per Day for the Split Rock Creek Subwatershed

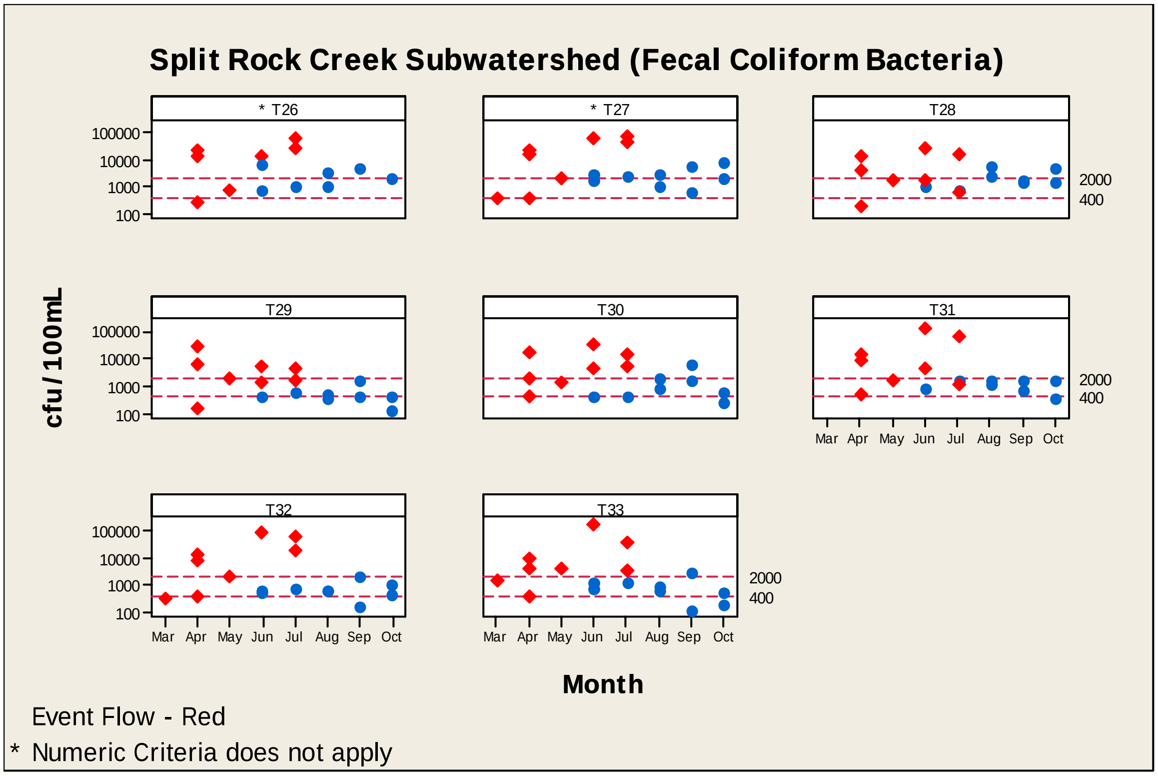


Figure 173. Scatterplot of Fecal Coliform Bacteria Grab Samples for the Split Rock Creek Subwatershed

Table 50 shows the ranges of fecal coliform bacteria (cfu/100mL), of TSS (mg/L), and the percent exceedences. It also shows the summer mean of total phosphorus (mg/L).

Table 50. Ranges and Percent Exceedences of Fecal Coliform Bacteria, TSS, and Summer Means of Total PO4 for the Split Rock Creek Subwatershed

Site	Fecal cfu/100mL	% fecal exceedence	TSS mg/L	% TSS exceedence	Summer Mean Total PO4 mg/L
T26	700-64000	--	4-249	--	0.60
T27	60-7400	--	12-1088	--	0.66
T28	580-25000	100	15-284	13	0.38
T29	310-5000	73	11-156	0	0.32
T30	400-36000	82	4-912	13	0.68
T31	600-137000	100	16-972	25	0.51
T32	160-96000	36	14-1580	29	0.64
T33	120-172000	46	3-1312	29	0.59

-- numeric standard not applicable

Based on the monitoring and modeling results Split Rock Creek Subwatershed accounts for 22 percent (includes the slices T31 and T33) of the total TSS loading to the Big Sioux River (R13) (Figure 62). A breakdown of this 22 percent is shown below, in Figure 174. The analysis for Figure 174 used the sampling months of Jul 00-Oct 00 and Mar 01-Oct 01. Since data was available for the months of Mar-Apr 2001, it was included in the analysis because it was more reflective of spring runoff conditions. See Appendix MM for pollutant load summary calculations.

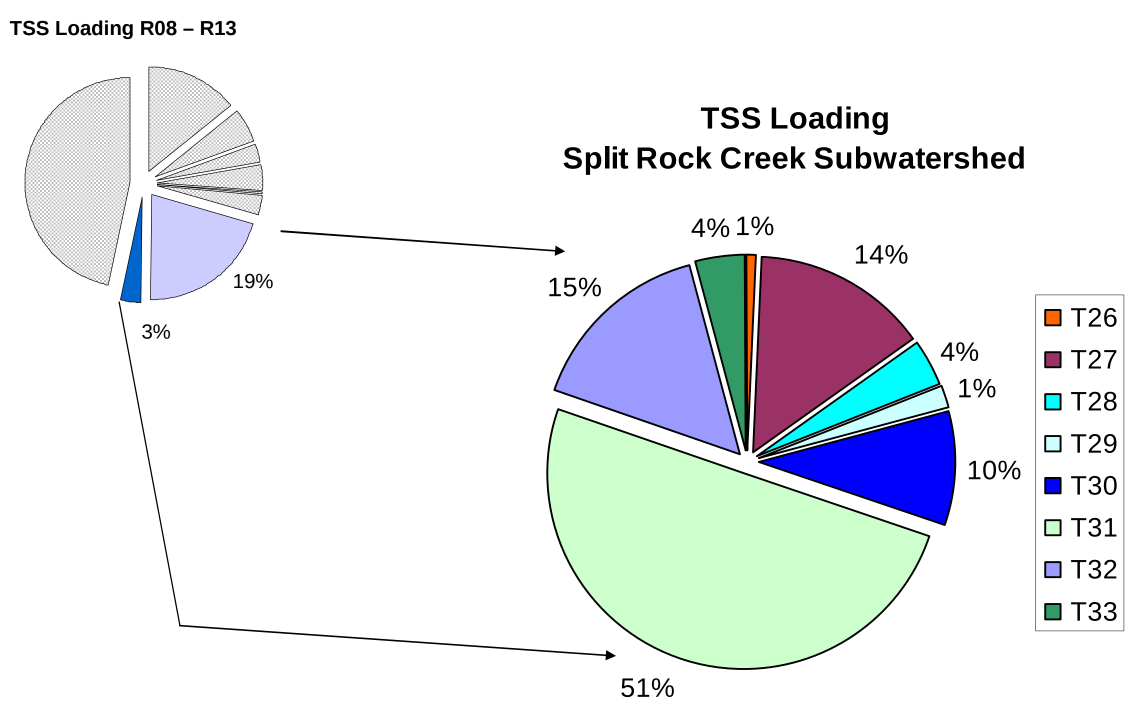


Figure 174. Percent Contributions of TSS Loading of the Split Rock Creek Subwatershed

The sediment loading above T31, minus T30 and T27, is 51 percent, which is 11.2 percent of the total sediment load at R13. This comprises an area of approximately 27,405 acres which yielded 3.0 tons of sediment per acre for the months that were monitored.

The sediment loading above T33 is four percent, which is actually 0.9 percent of the total sediment loading at R13. This comprises an area of approximately 27,184 acres which yielded 0.95 tons of sediment per acre for the months that were monitored.

The sediment loading above T27 is 14 percent, which is actually 3.08 percent of the total sediment loading at R13. This comprises an area of approximately 21,431 acres which yielded 1.17 tons of sediment per acre for the months that were monitored.

The sediment loading above T28 (four percent), T30 (10 percent), and T32 (15 percent) is 29 percent of the Split Rock Creek Watershed which is actually 6.38 percent of the total sediment loading at R13. This comprises an area of approximately 60 percent of the Split Rock Creek Subwatershed, which lies within Minnesota. The estimated sediment yield from Minnesota is 0.22 tons of sediment per acre for the months that were monitored.

The summer mean concentrations for total phosphorus at all sites in this watershed, with the exception of T29, are far greater (0.32-.068 mg/L) than the ecoregion mean of 0.30 mg/L (Fandrei et al. 1988). These higher numbers can be attributed to sources such as livestock and human waste, and also commercial fertilizers.

Biological and Physical Habitat Summary

Fish, habitat, and macroinvertebrates were collected for all the sites in the Split Rock Creek Subwatershed. Score sheets for each of these sites can be found in Appendix I for fishes, Appendix M for macroinvertebrates, and Appendix Q for habitat. Based on the biological and physical data, overall suggested impairment for these sites is listed in Table 51 and range from minimal to severe.

Data from Sites T28, T29, and T30 suggest minimal impairment. Site T30 had the most favorable scores within this subwatershed. These sites exhibited good species richness and benthic insectivore richness, in the fish category. Sites T29 and T30 each had one Blackside Darter, which is an insectivore that is listed as a rare species in the state of South Dakota. Also, two Topeka Shiners were found at T29, which are a sensitive, intolerant, and federally endangered fish species. Habitat showed moderate to heavy animal vegetation use and fair to excellent bed composition and bank stability. Macroinvertebrates for these three sites were very good with a high percentage of EPT, and HBI of 4.7 to 5.3, and a low percentage of tolerant organisms.

Sites T26, T27, T31, and T33 exhibited moderate to severe impairment. Site T33 may suggest a lesser amount of impairment due to the higher fish IBI. The high fish IBI can be attributed to the presence of a large, deep, isolated pool. When seined, this pool contained 23 species of fish. When avoiding the pool with the seine, only seven species (Stonecat, Johnny Darter, Common Shiner, Bluntnose Minnow, Sand Shiner, Bigmouth Shiner and Red Shiner) were found throughout the reach. Species richness was significantly lower than the minimally impaired sites with the exception of T33, if the pool was counted. Two Topeka shiners were found at T27 and one in the pool at T33. Seven Blackside Darters were found at T27 and T31, and one Blackside Darter in the pool at T33. Also, the state threatened Trout Perch was found at T31 and 24 of them were found in the pool at T33.

Habitat was poor at these locations. Site T33 scored the poorest, with zero bank stability and zero overhanging vegetation. Bed composition was very poor at T26 and T33. Site 27 had the best physical complexity. Animal vegetation use was low to moderate at these sites.

Site T32 suggests severe impairment. Fish and habitat are poor at this site. Fish IBI was indicated by low species richness, low benthic insectivore richness, and zero sensitive species. Habitat IPI showed no over hanging vegetation, and lack of physical complexity and bank stability. Surprisingly, macroinvertebrate IBI was 73, with an HBI of 4.7, a low percentage of tolerant species, and a high percentage of EPT.

Table 51. Final Index Values for Bugs, Fish, and Habitat for the Split Rock Creek Subwatershed

Site	Macroinverts	Fish	Habitat	Suggested Impairment
T26	60	52	43	Moderate to Severe
T27	76	64	46	Moderate to Severe
T28	74	73	56	Minimal
T29	65	80	67	Minimal
T30	76	76	64	Minimal
T31	70	54	50	Moderate to Severe
T32	73	46	34	Severe
T33	73	78	37	Moderate to Severe

Source Linkage and Conclusion

Based on modeling and loading calculations, fecal coliform bacteria (Table 52) and TSS (Table 53) would need the following reductions at each site:

Table 52. Percent Fecal Coliform Bacteria Reduction and Possible Sources for the Split Rock Creek Subwatershed

Site	Numeric Criteria	Fecal % Reduction * (Flow)	Event vs Base Flow	Possible Sources
T26	--	--	NA	NA
T27	--	--	NA	NA
T28	400	81 (H), 93 (M), 76 (MR), 91 (D), 79 (L)	Both	poor riparian areas, failing septics, instream livestock, inadequate manure application, and feedlot runoff
T29	400	69 (H), 83 (M), 65 (MR), 76 (L)	Event	poor riparian areas, failing septics, instream livestock, inadequate manure application, and feedlot runoff
T30	400	96 (H), 96 (MR), 82 (D)	Both	poor riparian areas, failing septics, instream livestock, inadequate manure application, and feedlot runoff
T31	400	99 (H), 82 (M), 71 (MR), 88 (D)	Both	poor riparian areas, failing septics, instream livestock, inadequate manure application, and feedlot runoff
T32	2000	98 (H), 93 (M)	Both	poor riparian areas, failing septics, instream livestock, inadequate manure application, and feedlot runoff
T33	2000	58 (H)	Both	poor riparian areas and failing septics

-- numeric standard not applicable
* Flow Ranges
H=High Flows (0-10%) M=Moist Conditions (10-40%) MR=Mid-Range Flows (40-60%)
D=Dry Conditions (60-90%) L=Low Flows (90-100%)

The monitoring data shows high fecal concentration during runoff events and non-event flows. Potential non-background non-point sources of fecal coliform bacteria would be failing septic systems, pastured livestock, inadequate manure application, and feedlot runoff. According to the feedlot inventory, there are 34 feedlots within the subwatershed, that lies in South Dakota, with a ranking ≥ 50 on a 0-100 scale. Livestock waste would contribute the higher fecal counts during runoff events. Whereas, livestock instream and failing septic systems contribute to the low flows concentration. According to the NPDES permit data, there were no point source discharges during the monitoring period. Therefore, reductions should focus on non-point sources (See TMDL Allocations in the Target Reductions and Priority Management Areas Section).

Table 53. Percent TSS Reduction and Possible Sources for the Split Rock Creek Subwatershed

Site	Numeric Criteria	TSS % Reduction	Possible Sources
T26	--	--	NA
T27	--	--	NA
T28	158	0	NA
T29	158	0	NA
T30	158	28	cropland erosion, streambank erosion, construction erosion
T31	158	62	cropland erosion, streambank erosion, construction erosion
T32	263	58	cropland erosion, streambank erosion, construction erosion
T33	263	20	cropland erosion, streambank erosion, construction erosion

Based on the current water quality criteria, TSS reduction is needed at T30, T31, T32, and T33. The 62 percent (T31) and 20 percent (T33) reductions correlate with the SDM findings of high erosion potential cropland encompassing over 63 percent of the land surface area within the watershed. The reductions at T30 and T32 could not be correlated with the SDM due to unavailable Minnesota data. There were no point sources identified as contributing to TSS during the monitoring period.

WATER QUALITY GOALS

Water quality goals are based on beneficial uses and standards to meet those uses. Based on monitoring results TSS, fecal coliform bacteria, and DO were the three parameters found not meeting the standards. DO was found to be a problem at only one monitoring location.

Silver Creek (T24) is the monitoring location with low dissolved oxygen levels. The goal for this site is to increase the DO levels by reducing phosphorus loadings and increasing streambank vegetation. These activities should reduce the excessive algae growth and provide shading which will reduce water temperatures.

Based on reducing loadings or concentrations to acceptable levels, goals were established for sites not meeting the TSS and fecal coliform bacteria water quality criteria. To meet the goals for DO, concentrations would also need to be increased.

To meet the water quality goals for fecal coliform bacteria, a numeric standard of either 400 cfu/100mL or 2000 cfu/100mL, depending on the location, must be applied. Likewise, to meet the water quality goals for TSS, a numeric standard of either 158 mg/L or 263 mg/L must be applied to achieve the reductions needed to meet the water quality goals of the Central Big Sioux River Watershed. DO was found to be a problem at only one location. To meet the water quality goal at this site, a DO concentration of $\geq$ 5 will need to be achieved.

The next two figures (Figures 175 and 176) show the percent exceedence of the standards for fecal coliform bacteria and TSS on a subwatershed basis. Exceedences for the monitoring locations within each subwatershed were averaged, based on 400cfu/100mL and 2000cfu/100mL, regardless of their current water quality criteria. As shown, the top three subwatersheds exceeding the fecal coliform standards are Jack Moore Creek, Slip-Up Creek, and Bachelor Creek. The top three subwatersheds exceeding the TSS standards are Slip-Up Creek, Split Rock Creek, and the BSR Direct Drainage Area (See Figure 177).

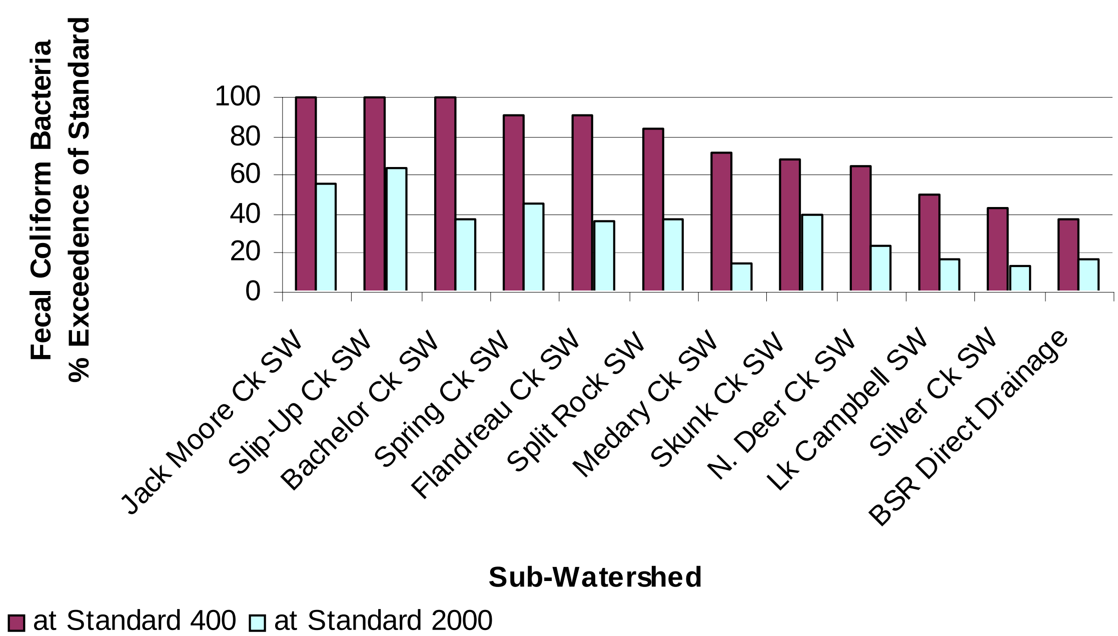


Figure 175. Percent Exceedence of Fecal Coliform Bacteria by Subwatershed

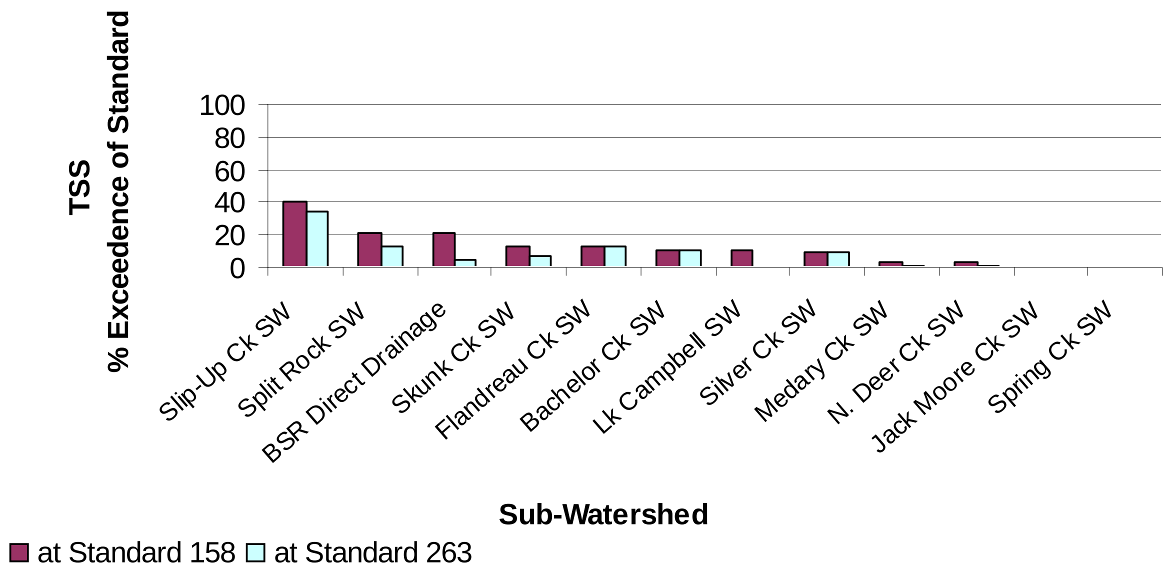


Figure 176. Percent Exceedence of TSS by Subwatershed

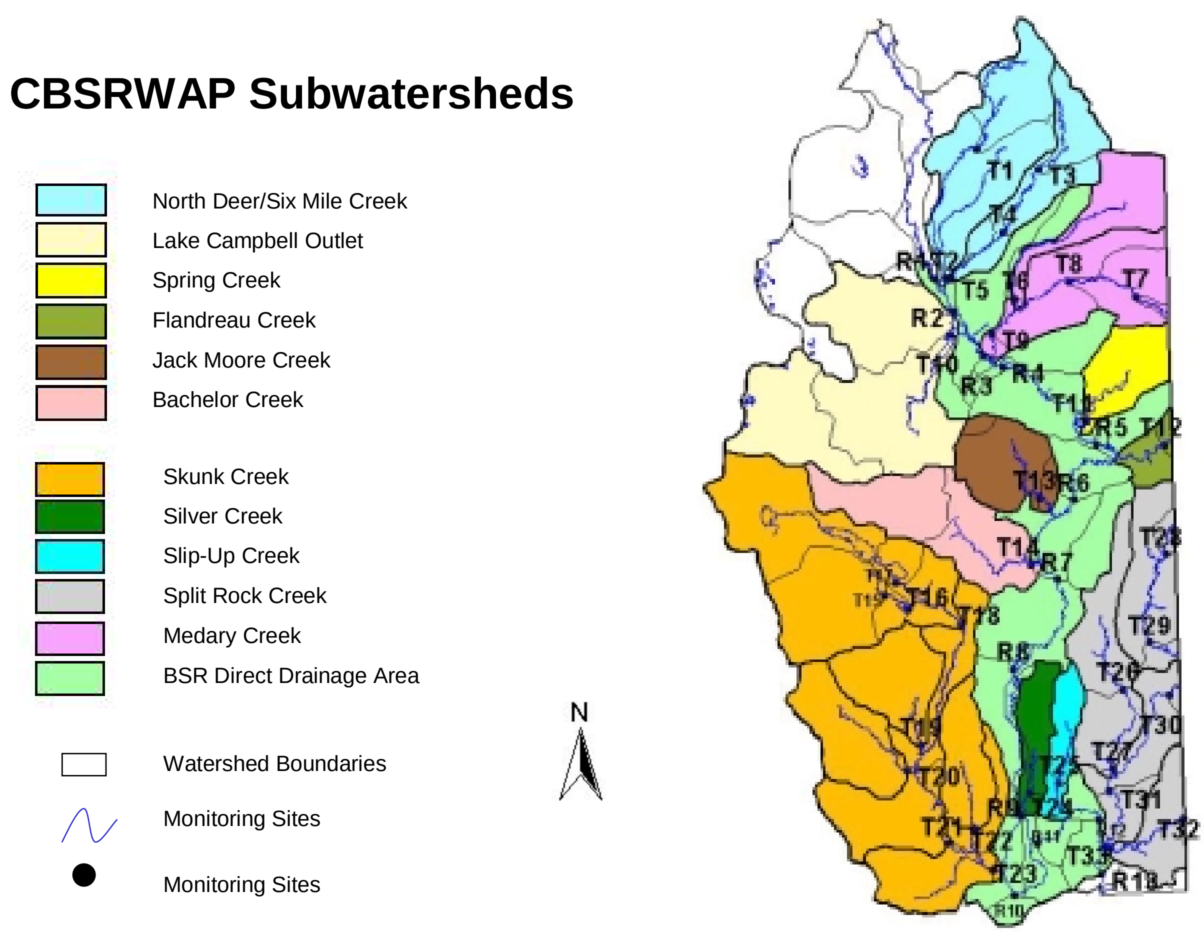


Figure 177. The 12 Major Subwatersheds of the CBSRW Study Area

CORRELATION AMONG THE PHYSICAL, BIOLOGICAL, AND CHEMICAL

Pearson's correlation (Table 54) and linear regression (Table 55) were used to analyze the index scores of the physical and biological components, as well as the scores for TSS and fecal coliform bacteria. Only those locations monitored for all of these components were used, n=27. The percent reductions calculated for each site were converted to a standard score. For example, if a site required a 25 percent reduction in TSS, the site was given a score of 75 out of 100. The percent reduction for fecal coliform bacteria for each site were derived by comparing the load at the median flow to the median sample load across all five hydrologic zones and then converting it to a standard score.

Table 54. Pearson's Correlation Among the Physical, Biological, and Chemical

Pearson Correlation				
X	Alternative Hypothesis	Y	P-value	R
TSS	≠	bugs	0.104	-0.32
TSS	≤	bugs	0.052	-0.32
TSS	≥	bugs	0.948	-0.32
TSS	≠	fish	0.166	0.27
TSS	≤	fish	0.917	0.27
TSS	≥	fish	0.083	0.27
TSS	≠	habitat	0.083	0.34
TSS	≤	habitat	0.959	0.34
TSS	≥	habitat	0.041	0.34
Fecal	≠	bugs	0.450	-0.15
Fecal	≤	bugs	0.225	-0.15
Fecal	≥	bugs	0.775	-0.15
Fecal	≠	fish	0.881	-0.03
Fecal	≤	fish	0.441	-0.03
Fecal	≥	fish	0.559	-0.03
Fecal	≠	habitat	0.257	-0.23
Fecal	≤	habitat	0.129	-0.23
Fecal	≥	habitat	0.871	-0.23
bugs	≠	fish	0.025	0.43
bugs	≤	fish	0.987	0.43
bugs	≥	fish	0.013	0.43
habitat	≠	fish	0.094	0.33
habitat	≤	fish	0.953	0.33
habitat	≥	fish	0.047	0.33

Based on a 95 percent confidence interval with a statistical significance of $p < 0.05$, the data show there is a relationship between

(1) fish/macroinvertebrates and water quality
(2) fish and macroinvertebrates

Although the R-square and R values are low, it suggests that there is a correlation among these groups.

Table 55. Linear Regression Among the Physical, Biological, and Chemical

Linear Regression				
Y		X	P-value	R^2
bugs	vs	TSS	0.104	0.10
fish	vs	TSS	0.166	0.08
habitat	vs	TSS	0.083	0.12
fish	vs	Fecal	0.881	0.00
bugs	vs	Fecal	0.450	0.02
habitat	vs	Fecal	0.257	0.05
fish	vs	bugs	0.025	0.18
fish	vs	habitat	0.094	0.11
TSS	vs	fish/bugs	0.012	0.31
Fecal	vs	fish/bugs	0.742	0.02

Collection of the physical and biological data is important because it helps to show the long-term effects of what is happening in the watershed. Macroinvertebrates and fishes are sensitive to their environments. Thus, biological indicators can be a useful tool in monitoring the health of streams and can ultimately assist in the establishment of management initiatives to help resolve water quality problems throughout the watershed.

To determine relative impairment of a site (least impaired to most impaired), scores from the IBI, IPI, standardized HBI, and standardized reductions of TSS and fecal coliform bacteria were totaled. The site receiving the highest score became the least impaired, and the site receiving the lowest score became the most impaired.

Figure 178 shows the BSR sites from least to most impaired. Fish and habitat IBI scores were absent for the river sites. Figure 179 shows the tributary sites from least to most impaired. In this figure scores from IBI, IPI, standardized HBI, and standardized reductions of TSS and fecal coliform bacteria were used.

Figures 179a and 179b show the tributary sites that were outliers due to not having macroinvertebrate IBI and standardized HBI (Figure 179a) and not having fish IBI and habitat IBI (Figure 179b).

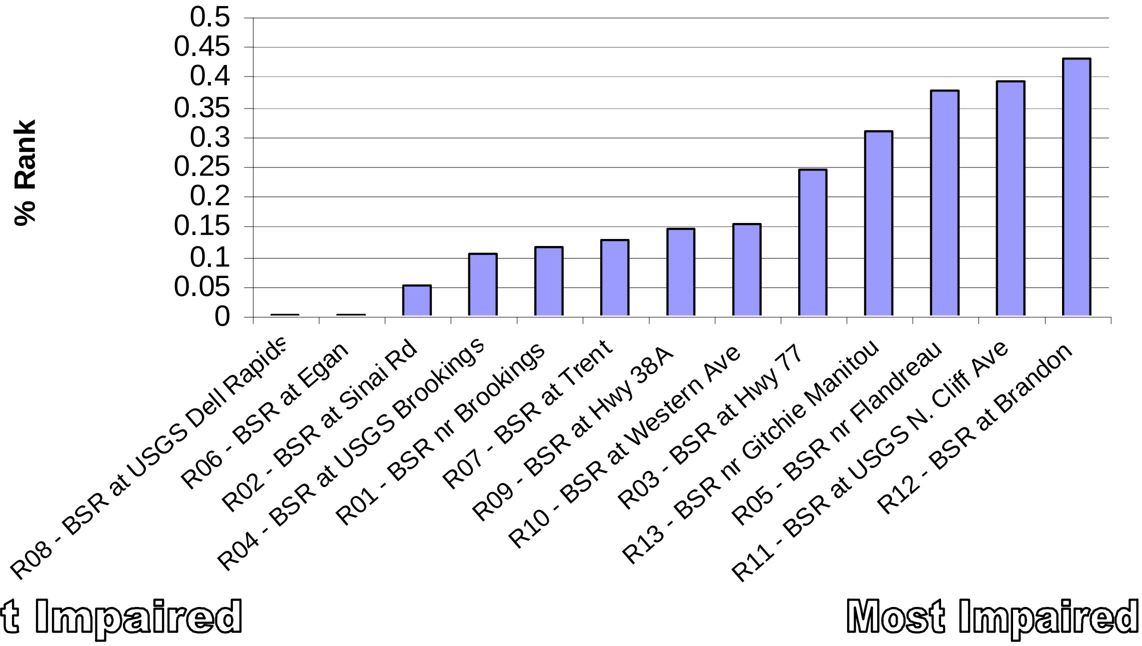


Figure 178. Least Impaired to Most Impaired River Sites

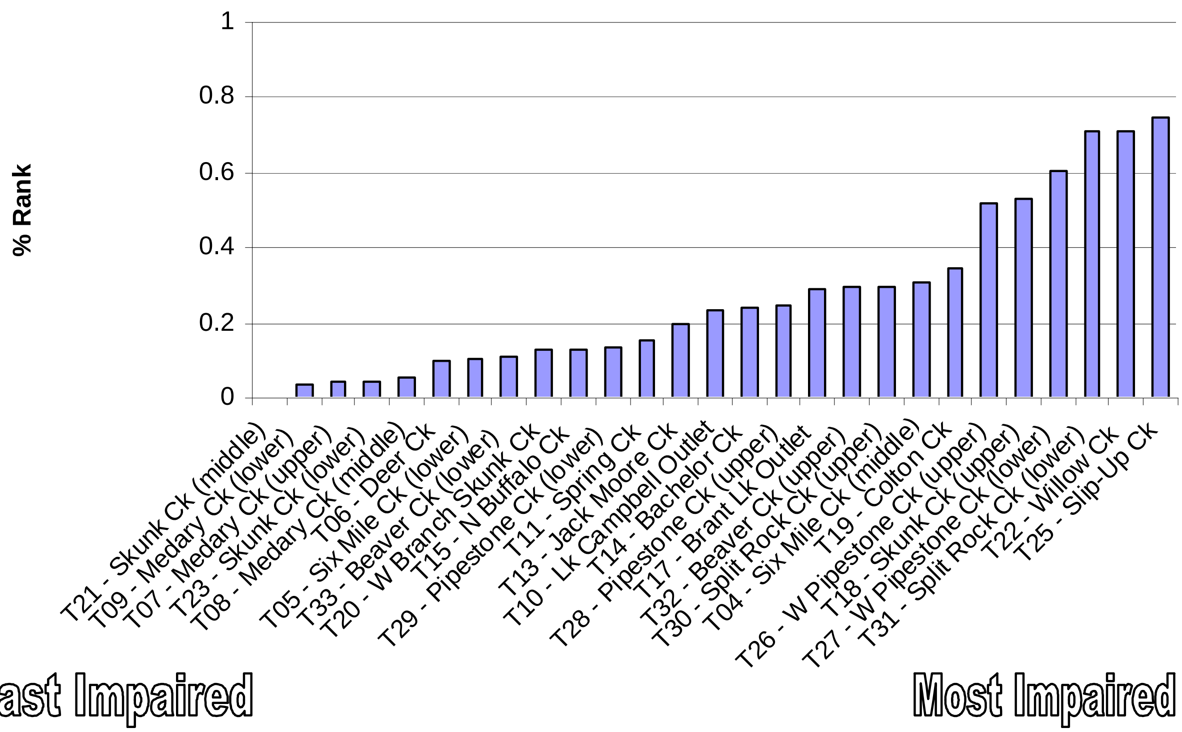


Figure 179. Least Impaired to Most Impaired Tributary Sites

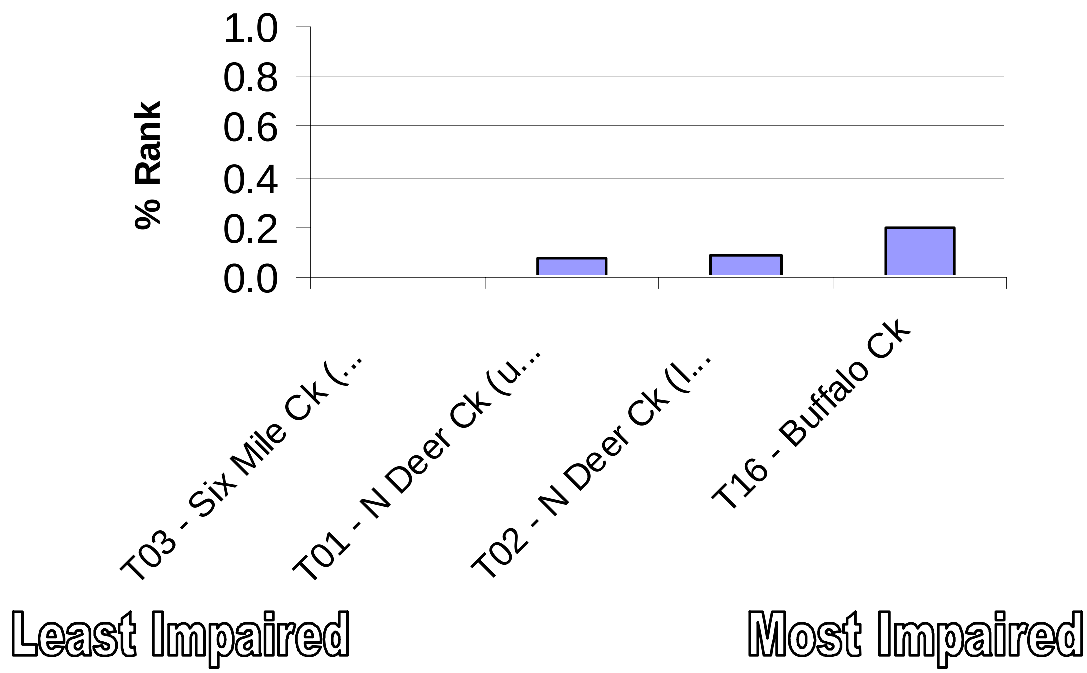


Figure 179a. Least Impaired to Most Impaired Tributary Sites Without Bug Data

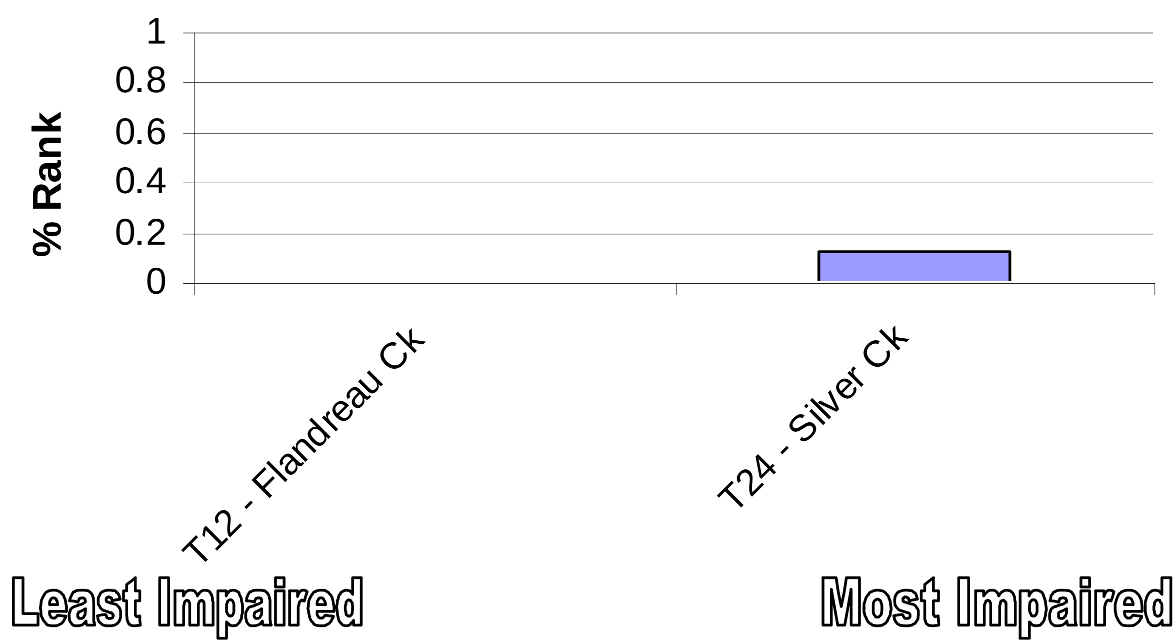


Figure 179b. Least Impaired to Most Impaired Tributary Sites Without Fish and Habitat Data

TSS TARGET REDUCTIONS AND PRIORITY MANAGEMENT AREAS

Table 56. TSS Priority Management Areas

Site	LMU (s)	% Loadings	% Reductions	Comments
R13	R13, GG, HH	53.00	72	Based on 158mg/L
T31	31, DD	11.20	62	Based on 158mg/L
R01	R01, above R01	6.48	10	Based on 158mg/L
R09	R09, R04-R08, AA, N, L, R, U, P, W	7.08	11	Based on 158mg/L
R11	R11, R10, JJ, II, CC	4.00	22	Based on 158mg/L
T33	33	3.08	20	Based on 263mg/L, 52% at 158mg/L
* T27	27	3.08	NA	43% at 263mg/L 66% at 158mg/L
R12	R12, EE, FF	3.00	30	Based on 158mg/L
T32	Minnesota	3.30	58	Based on 263mg/L, 75% at 158mg/L
R03	R03, R02, C, I, O	1.92	17	Based on 158mg/L
T30	Minnesota	2.20	28	Based on 158mg/L
T23	23, 21, BB, Y	0.84	10	Based on 263mg/L at T21 46% at 158mg/L At T21
T12	Minnesota	0.48	0	Based on 263mg/L, 18% at 158mg/L
* T22	22	0.34	NA	16% at 263mg/L 50% at 158mg/L
* T19	19	0.30	NA	0% at 263mg/L 36% at 158mg/L
* T25	25	0.23	NA	17% at 263mg/L 50% at 158mg/L

* WQ criteria for TSS not applicable at this site

Table 56 lists the TSS priority management areas by order of percent loadings. These loadings represent what is occurring at that site. The percent reduction needed is based on currently assigned standards. The LMU's associated with each site may or may not also require reductions based on water quality monitoring data. See Appendix MM for reductions needed at each site. Sites with an asterisk indicate monitoring location does not have TSS water quality criteria associated with it. However, TSS contributions from these areas require reductions to reduce loadings at downstream locations.

Site R02 did not show a need for reduction, however since it is listed as not meeting TSS water quality criteria for its beneficial uses, it has been included as part of priority management area R03.

Site R05 did not show a need for reduction, however since it is listed as not meeting water quality criteria for its beneficial uses it has been included as part of priority management area R09.

T10 and T14 are not listed as a priority for this project because they already have approved TMDL assessments.

A TSS standard is not applicable for site T27. However, if a standard of 158 mg/L were applied, it would require a 66 percent reduction. T27 has a somewhat significant contribution to the overall project area and it does drain into Split Rock Creek which currently has a TSS standard of 158 mg/L. Thus, it is listed as a priority area.

A TSS standard is not applicable for site T20 or T26, and even if a standard of 158 mg/L were applied, neither would require a reduction. Therefore, they are not listed as priority areas.

A TSS standard is not applicable for site T22. However, if a standard of 263mg/L were applied, it would require a 16 percent reduction. This site is listed as a priority area because it requires a reduction to meet the goal of T23 (Skunk Creek) which has a TSS standard of 263 mg/L.

Site T28 meets the TSS water quality criteria for its beneficial uses and is not listed as a priority because it requires zero percent reduction and most of the watershed area lies within Minnesota.

A TSS standard is not applicable for Site T25, however if a standard of 158mg/L were applied, it would require a 50 percent reduction. T25 is does not significantly contribute to the overall project area, but this stream drains into the BSR above R12, which has a TSS standard of 158 mg/L. Thus, it is listed as a priority area.

Figure 180 shows the TSS priority areas by color code. Non-shaded areas do not require a sediment reduction. Table 56 and Figure 180 were constructed based on individual monitoring site data. However, the TSS TMDLs for this assessment are evaluated based on segments, not by individual site (See Future Activity Recommendations section). A list of proposed TSS TMDLs are shown on Table 62. Individual TMDL reports can be found throughout Appendices SS through FFF. A TSS TMDL priority management map can be found in Appendix RR1.

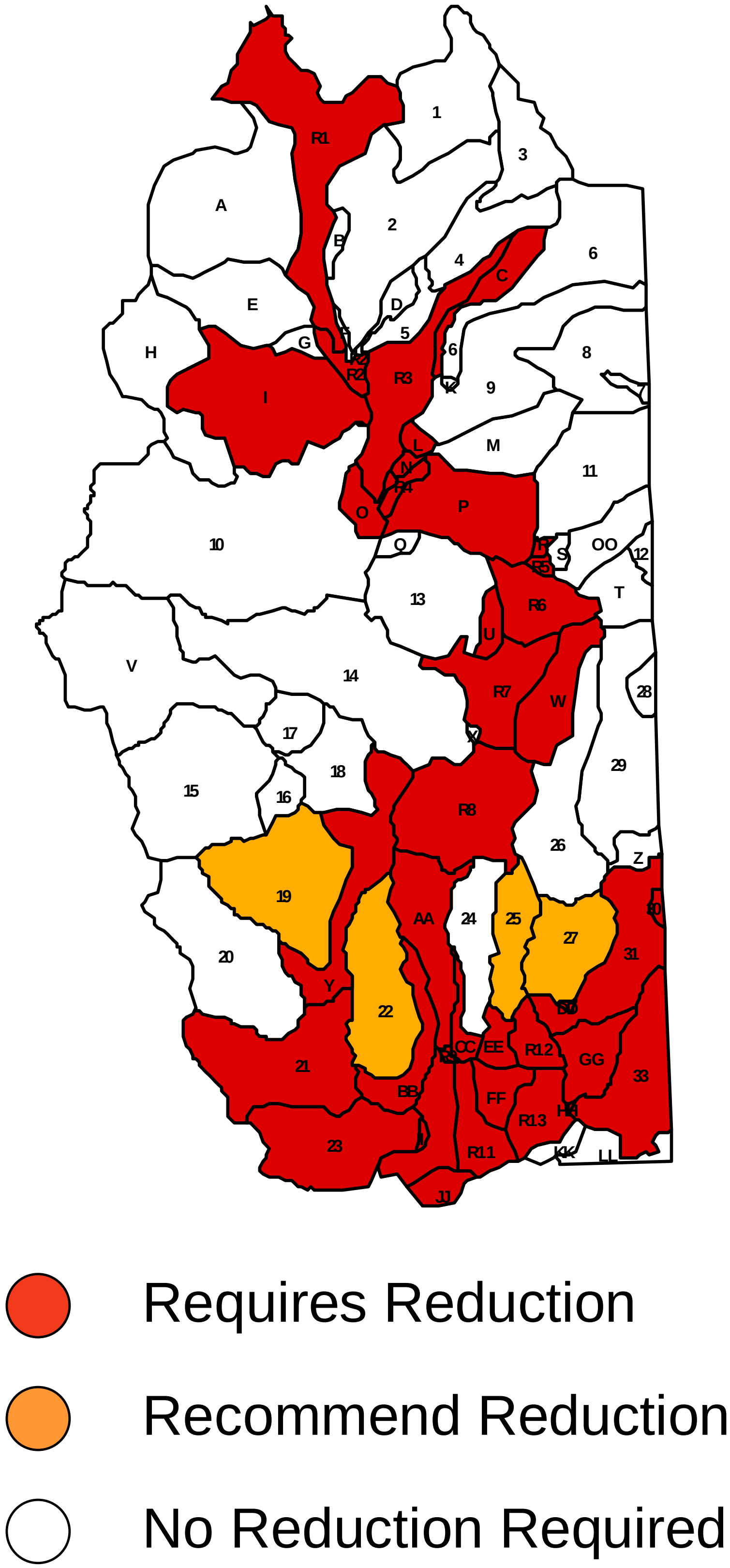


Figure 180. TSS Priority Management Areas as Related to Table 56

TARGET REDUCTIONS AND PRIORITY MANAGEMENT AREAS FOR FECAL COLIFORM BACTERIA

The following fecal coliform bacteria priority management tables have been categorized into five hydrologic conditions; (1) High Flows, (2) Moist Conditions, (3) Mid-Range Flows, (4) Dry Conditions, and (5) Low Flows. Each hydrologic condition table has been further categorized based upon needed reductions. These categories are as follows:

I.	Areas needing immediate attention	95% - 100 % reduction needed
II.	Very poor areas	75% - 94% reduction needed
III.	Poor areas	50% - 74% reduction needed
IV.	Fair areas	25% - 49% reduction needed
V.	Good areas	6% - 24% reduction needed
VI.	Excellent areas	0% - 5% reduction needed

Each of the five hydrologic conditions is separated into priority areas (See Tables 57, 58, 59, 60, and 61). Each priority area is listed by order of total CFU load for the season (May-Sept). Priority Area I lists those sites in need of immediate attention and is color coded red. With reductions needed ranging from 95 to 100 percent. Priority Area II lists those sites in very poor condition, with reductions ranging from 75 to 94 percent reductions needed and is color coded orange. Priority Area III lists those sites that are in poor condition, with reduction needed ranging from 50 to 74 percent and is color coded yellow. Priority Area IV lists the sites that are in fair condition, with reductions ranging from 25 to 49 percent and is color coded green. Priority Areas V and VI list the remaining sites that are in good to excellent condition, but may still require some reduction of fecal coliform bacteria. Each hydrologic table is associated with a priority area map (See Figures 181, 182, 183, 184, and 185). LMUs A, E, G, H, KK, and LL are omitted from this discussion as they are outside the study area.

Figure 185 is a consolidation of Tables 57 through 61. Any site listed in Priority Area I, on each of the five tables, were merged together to form Priority Area I on Figure 186. If a monitoring location was found in more than one priority area across the hydrologic zones, then the highest priority area took precedence, and that site was incorporated into the highest priority area in Figure 186. Figure 186, gives an overall view of where fecal coliform bacteria are a problem and where best management practices should be targeted.

It is important to note these tables and figures are constructed on a site by site basis without regard to number of samples in each hydrologic zone. Therefore, those zones with few samples may reflect a higher percent reduction than necessary.

The fecal coliform bacteria TMDLs for this assessment are evaluated by segment, not by individual monitoring site. A list of proposed TMDLs is shown in Table 62. Individual TMDL reports can be found throughout Appendices SS through FFF. A fecal coliform bacteria TMDL priority management map can be found in Appendix RR1.

Table 57. Fecal Coliform Bacteria Reductions for High Flows Hydrologic Condition

High Flows

Site	LMU's	Load	% Reduction
Priority Area I Category: Immediate Attention Reductions: 95%-100%			
Site	**LMU's**	**Load**	**% Reduction**
* T27 *	27	4.01E+07	100
T31	31, DD	2.67E+07	99
R09	R9, AA	6.90E+07	99
* T19 *	19	2.87E+07	99
* T25 *	25	1.21E+06	99
T23	23, BB	4.43E+07	98
T32	Minnesota	1.36E+07	98
T13	13, Q	8.30E+05	97
* T20 *	20, Y	1.32E+07	97
* T22 *	22	1.00E+07	97
R12	R12, EE, FF	1.32E+07	96
T30	30, Minnesota	5.43E+06	96
R13	R13, GG, HH	1.09E+07	95
Priority Area II Category: Very Poor Reductions: 75%-94%			
Site	**LMU's**	**Load**	**% Reduction**
T24	24	7.64E+06	93
* T08 *	8	6.60E+05	92
R10	R10, II	5.61E+06	91
T21	21	1.48E+07	89
T12	12, Minnesota	1.96E+06	88
T04	4	3.92E+05	87
T28	28, Minnesota	7.43E+05	81
T14	14	1.73E+05	80
T05	5, D	2.32E+05	79
R11	R11, JJ, CC	5.32E+06	76
Priority Area III Category: Poor Reductions: 50%-74%			
Site	**LMU's**	**Load**	**% Reduction**
T11	11	5.09E+05	72
T29	29, Z	7.27E+05	69
* T15 *	15	8.59E+05	64
T33	33	2.49E+06	58
Priority Area IV Category: Fair Reductions: 25%-49%			
Site	**LMU's**	**Load**	**% Reduction**
R08	R8, W	1.43E+06	29
Priority Area V Category: Good Reductions: 6%-24%			
Site	**LMU's**	**Load**	**% Reduction**
T17	17, V	1.04E+06	20

* * Monitoring Site has no WQ standard for fecal coliform

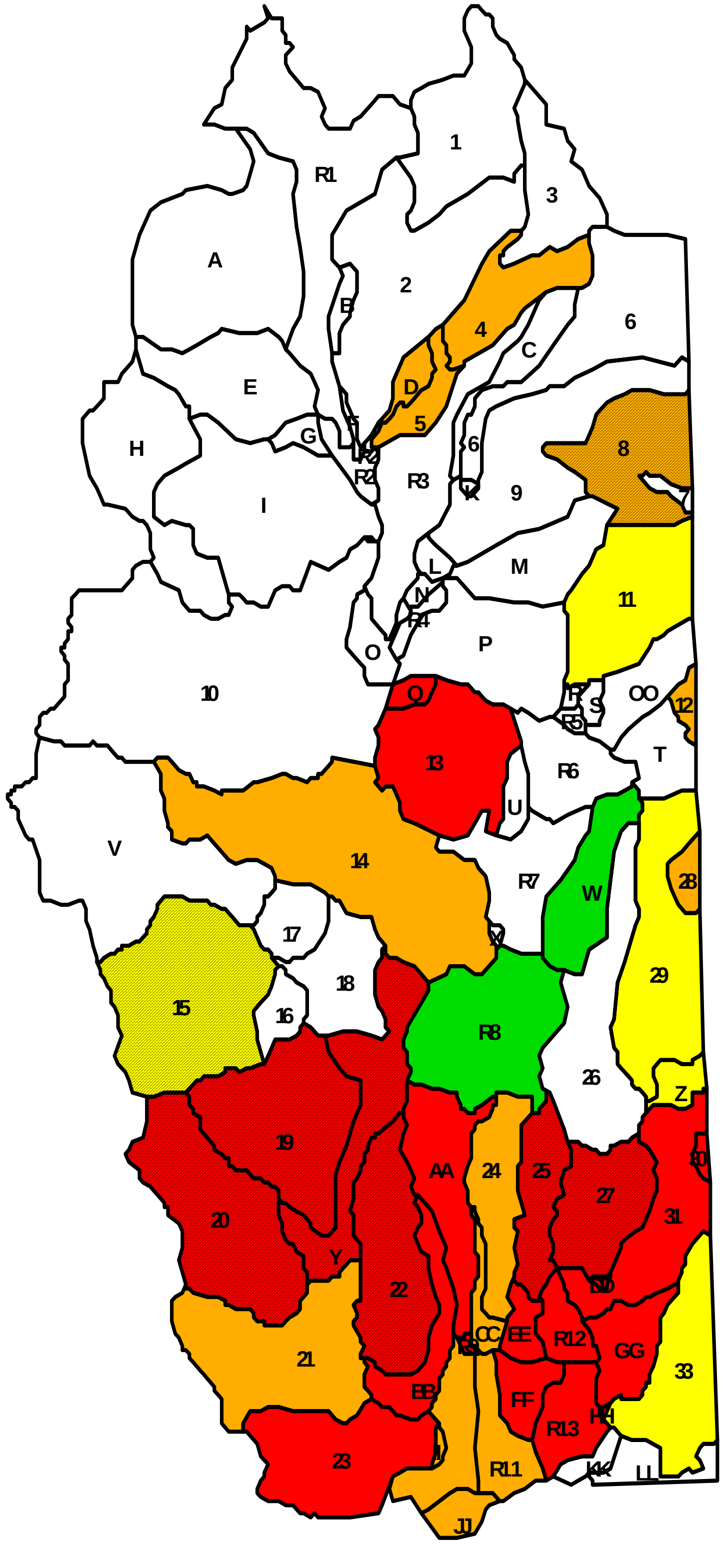


Figure 181. Fecal Coliform Bacteria High Flow Conditions Priority Management Areas

Table 58. Fecal Coliform Bacteria Reductions for Moist Hydrologic Condition

Moist Conditions			
Priority Area I **Category: Immediate Attention** **Reductions: 95%-100%**			
Site	**LMU's**	**Load**	**% Reduction**
* T26 *	26	8.49E+05	98
* T27 *	27	2.02E+06	99
Priority Area II **Category: Very Poor** **Reductions: 75%-94%**			
Site	**LMU's**	**Load**	**% Reduction**
R10	R10, II	2.43E+06	94
T28	28, Minnesota	2.47E+05	93
* T15 *	15	4.94E+05	93
T32	Minnesota	1.77E+06	93
T31	31, DD	1.42E+05	82
T29	29, Z	1.56E+05	83
Priority Area III **Category: Poor** **Reductions: 50%-74%**			
Site	**LMU's**	**Load**	**% Reduction**
* T19 *	19	9.33E+04	69
* T25 *	25	1.10E+04	63
T12	12, Minnesota	9.73E+04	55
Priority Area IV **Category: Fair** **Reductions: 25%-49%**			
Site	**LMU's**	**Load**	**% Reduction**
T05	5, D	2.68E+04	39
Priority Area V **Category: Good** **Reductions: 6%-24%**			
Site	**LMU's**	**Load**	**% Reduction**
* T22 *	22	1.88E+04	14

* * Monitoring Site has no WQ standard for fecal coliform

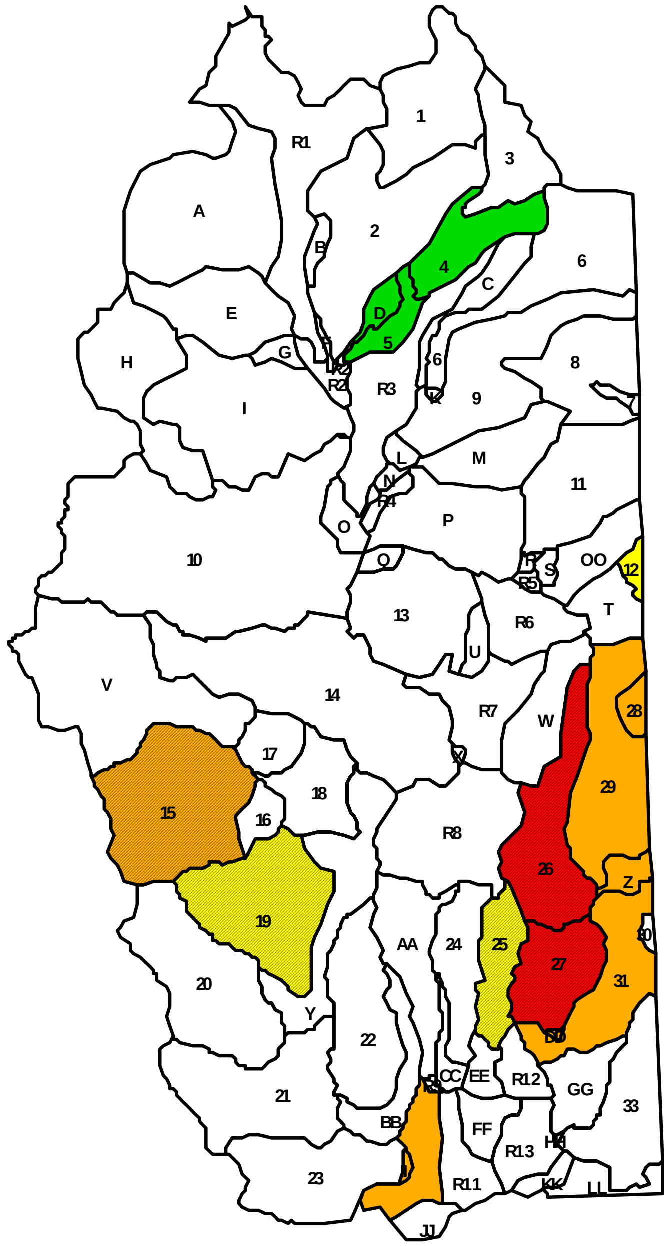


Figure 182. Fecal Coliform Bacteria Moist Conditions Priority Management Areas

Table 59. Fecal Coliform Bacteria Reductions for Mid-Range Flows Hydrologic Condition

Mid-Range Flows			
Priority Area I			
Category: Immediate Attention			
Reductions: 95%-100%			
Site	**LMU's**	**Load**	**% Reduction**
T30	30, Minnesota	4.49E+05	96
Priority Area II			
Category: Very Poor			
Reductions: 75%-94%			
Site	**LMU's**	**Load**	**% Reduction**
* T27 *	27	3.20E+04	81
T28	28, Minnesota	1.96E+04	76
Priority Area III			
Category: Poor			
Reductions: 50%-74%			
Site	**LMU's**	**Load**	**% Reduction**
T31	31, DD	3.18E+04	71
T29	29, Z	4.19E+04	65
* T25 *	25	2.66E+03	59
T18	18	2.29E+04	51
Priority Area IV			
Category: Fair			
Reductions: 25%-49%			
Site	**LMU's**	**Load**	**% Reduction**
* T20 *	20, Y	1.75E+04	49
* T26 *	26	2.00E+03	46
T02	2	2.27E+04	40
Priority Area V			
Category: Good			
Reductions: 6%-24%			
Site	**LMU's**	**Load**	**% Reduction**
T06	6	7.76E+03	14
* * Monitoring Site has no WQ standard for fecal coliform			

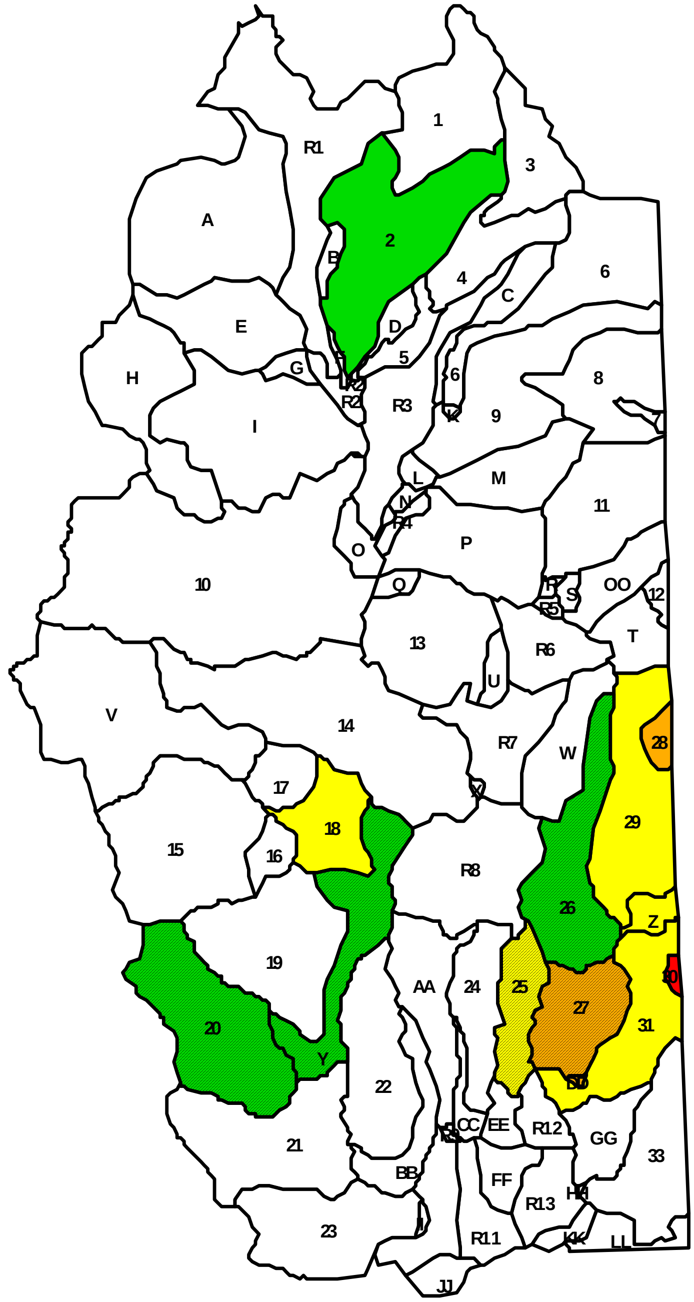


Figure 183. Fecal Coliform Bacteria Mid-Range Flows Priority Management Areas

Table 60. Fecal Coliform Bacteria Reductions for Dry Hydrologic Condition

Dry Conditions			
Priority Area I **Category: Immediate Attention** **Reductions: 95%-100%**			
Site	**LMU's**	**Load**	**% Reduction**
T18	18	1.98E+06	100
Priority Area II **Category: Very Poor** **Reductions: 75%-94%**			
Site	**LMU's**	**Load**	**% Reduction**
* T25 *	25	7.52E+03	92
T17	17, V	3.45E+05	91
* T26 *	26	3.31E+03	91
T28	28, Minnesota	3.20E+04	91
T31	31, DD	2.69E+04	88
* T27 *	27	1.64E+04	83
T30	30, Minnesota	3.09E+04	82
* T19 *	19	1.07E+04	77
Priority Area III **Category: Poor** **Reductions: 50%-74%**			
Site	**LMU's**	**Load**	**% Reduction**
R13	R13, GG, HH	4.23E+04	69
* T15 *	15	8.75E+03	67
R06	R6, OO, T, S	3.45E+05	61
Priority Area IV **Category: Fair** **Reductions: 25%-49%**			
Site	**LMU's**	**Load**	**% Reduction**
R12	R12, EE, FF	2.04E+04	39

* * Monitoring Site has no WQ standard for fecal coliform

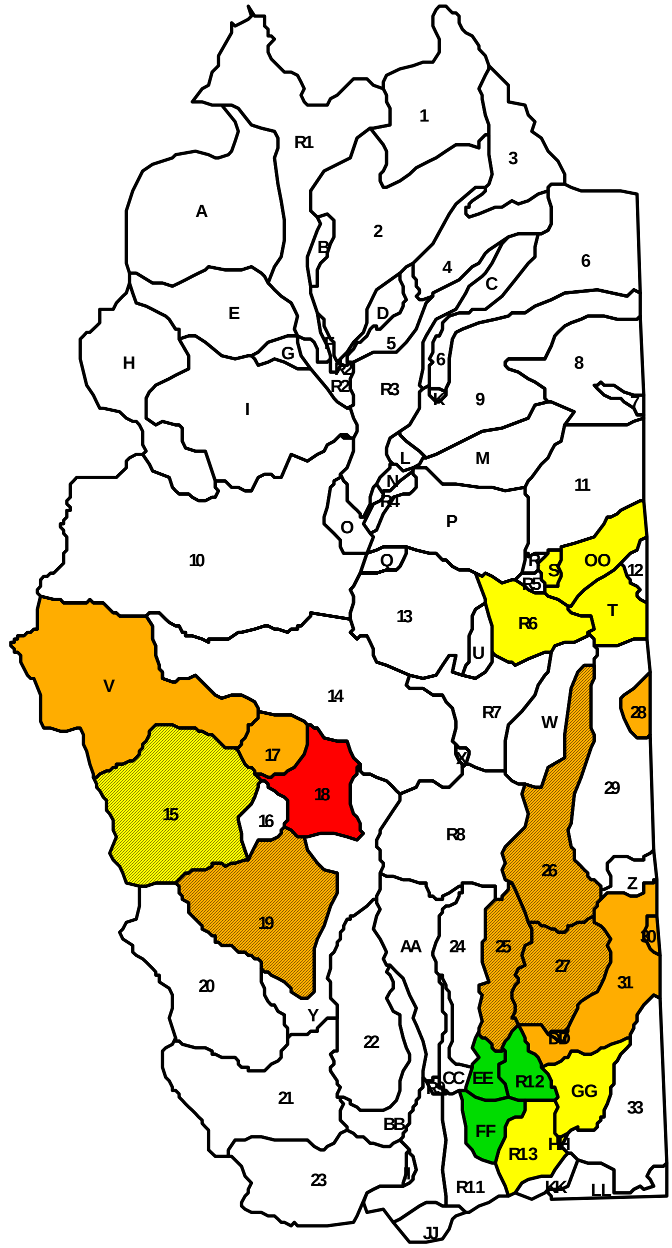


Figure 184. Fecal Coliform Bacteria Dry Conditions Priority Management Areas

Table 61. Fecal Coliform Bacteria Reductions
for Low Flow Hydrologic Condition

Low Flows			
Priority Area II **Category: Very Poor** **Reductions: 75%-94%**			
Site	**LMU's**	**Load**	**% Reduction**
* T26 *	26	3.27E+02	93
* T25 *	25	6.66E+03	92
T27	27	1.54E+04	88
T28	28, Minnesota	8.46E+03	79
T29	29, Z	5.01E+04	76
Priority Area III **Category: Poor** **Reductions: 50%-74%**			
Site	**LMU's**	**Load**	**% Reduction**
R11	R11, JJ, CC	1.45E+04	52
Priority Area IV **Category: Fair** **Reductions: 25%-49%**			
Site	**LMU's**	**Load**	**% Reduction**
T13	13, Q	2.45E+01	44
Priority Area V **Category: Good** **Reductions: 6%-24%**			
Site	**LMU's**	**Load**	**% Reduction**
T05	5, D	8.99E+02	21

* * Monitoring Site has no WQ standard for fecal coliform

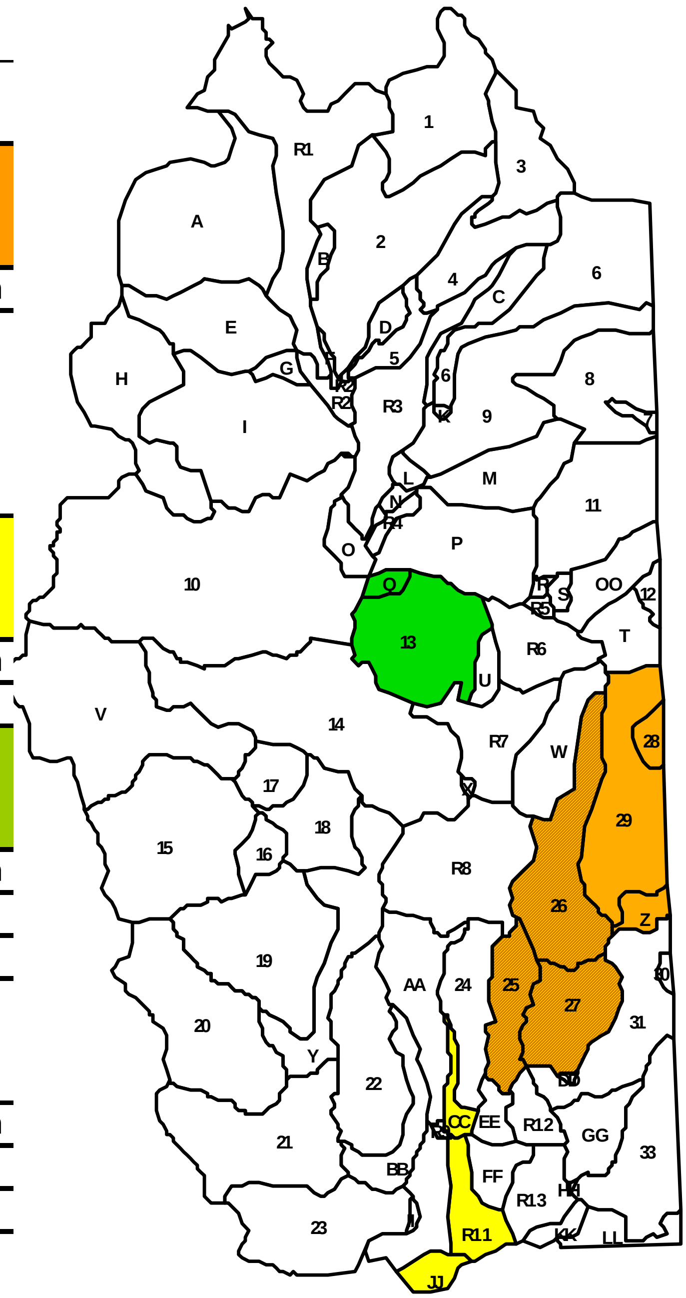


Figure 185. Fecal Coliform Bacteria Low Flow
Priority Management Areas

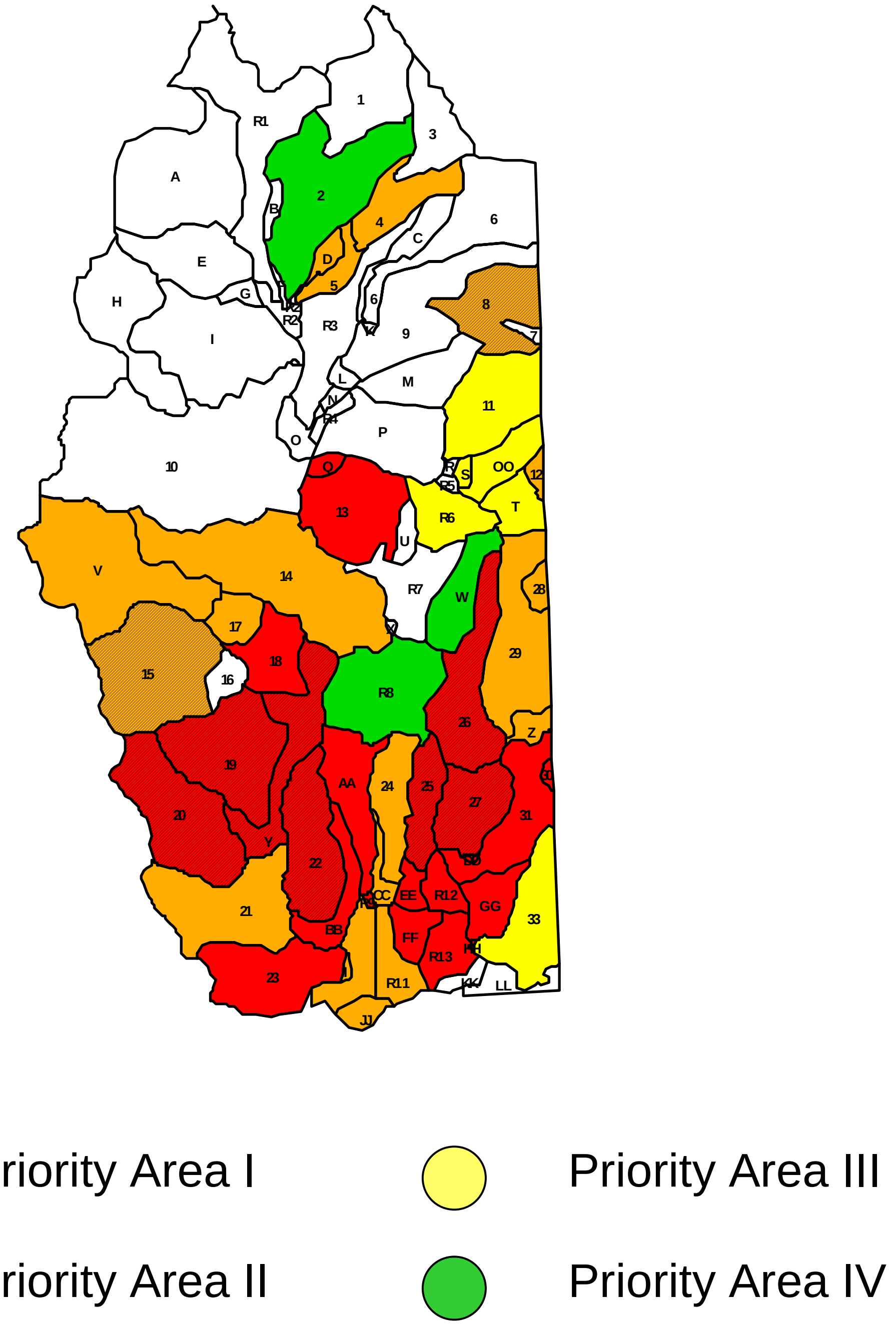


Figure 186. Consolidated Priority Management Areas for Fecal Coliform Bacteria

FUTURE ACTIVITY RECOMMENDATIONS

Water quality numeric standards are assigned by a stream segment basis. However, when looking at this study area, which encompasses several streams and associated watersheds, there are some inconsistencies in regards to assigned water quality standards. Rule **74:51:01:04 Application of criterion to contiguous water** states,

> "*If pollutants are discharged into a segment and the criteria for that segments designated beneficial use are not exceeded but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, that pollutants may not cause the more stringent criteria to be exceeded.*"

According to this rule, if a segment assigned a particular numeric standard runs into another segment with a more stringent numeric standard, then the more stringent standard should be used to assess the pollutants in the stream. Therefore, to meet the water quality goals for fecal coliform bacteria and TSS, streams with less stringent standards and/or those with no standards at all, should be identified as priority management areas to achieve the reductions needed to meet the water quality goals of the Central Big Sioux River Watershed.

Appendix QQ and RR contains a flow chart of the tributaries and rivers in the study area. It represents the sequential flow process and also shows the numeric standards assigned to the areas. An example of the problem presented can be seen on the TSS flow chart (Appendix QQ), where the Big Sioux River system is assigned a numeric standard of 158 mg/L, however several tributary systems flowing into the BSR are assigned a less stringent numeric standard of 263 mg/L. There is also the problem of major tributary systems that have no numeric standards assigned, which are flowing into other tributaries or even the BSR with a numeric standard assigned.

The same problem exists with the fecal coliform bacteria standards (See Appendix RR). In addition to having tributaries with less stringent standards flowing into the BSR, the BSR itself has a standard of 2000 cfu/100mL assigned from R01 to R07, and then a more strict standard (400 cfu/100mL) assigned from R08 to R13.

This report was based upon the currently assigned numeric standards for water quality. However, for an implementation program to work throughout this area, which encompasses many subwatersheds, the current numeric standards should be re-assessed and those areas without numeric standards should be assigned comparable ones.

For the purpose of this assessment, TMDLs will be approached on a segment by segment basis, assuming the TMDL of the preceding segment will be reached. Table 62 shows the proposed TMDL list. At this time, 22 TMDLs are proposed – eight for TSS and 14 for fecal coliform bacteria. The reports will focus on the segments that were listed in the 305 (b) Water Quality Assessment, and any other subwatersheds not meeting the water quality criteria. The four segments of the Big Sioux River running through the City of Sioux Falls area will need further evaluation before TMDL finalization. Therefore, they are not submitted with this report. The TMDL reports can be found in Appendices SS through FFF. Refined maps of the areas requiring reductions based on the results of the TMDL reports can be found in Appendix RR1.

Table 62. Proposed TMDL Listing of Areas Not Meeting Water Quality Criteria

Listed Areas			Other Areas		
Segment	**Affected Sites**	**Cause**	**Tributary**	**Affected Sites**	**Cause**
Brookings to I-29	T01-T09, T10 R01-R04	TSS	North Deer Creek (Near Bruce to Near Brookings)	T02	Fecal
I-29 to Near Dell Rapids	R04-R08 T11-T14	TSS	Six Mile Creek (Near White to Near Brookings)	T04, T05	Fecal
Near Dell Rapids to Below Baltic	R08	Fecal	Spring Creek	T11	Fecal
** Below Baltic to Skunk Creek	R08-R10 T15-T23	TSS Fecal	Flandreau Creek	T12	Fecal
** Skunk Creek to Diversion Return	R10, R11	TSS Fecal	Jack Moore Creek	T13	Fecal
** Diversion Return to SF WWTF	R11, T25	TSS Fecal	* Bachelor Creek	T14	Fecal
** SF WWTF to Above Brandon	R12	TSS Fecal	Split Rock Creek	T26-T33	TSS Fecal
			Beaver Creek	T32, T33	TSS Fecal
			Pipestone Creek	T28, T29	Fecal
			Skunk Creek	T18, T21, T23	Fecal

* A TMDL has previously been submitted during another assessment

** Further evaluation needed before TMDL finalization - TMDL will be submitted at a later time

BEST MANAGEMENT PRACTICES

Table 63 contains a recommended list of reductions that were selected based on fecal coliform bacteria, TSS, and nutrients needed for each site. Nutrients are listed because they are directly correlated to the reductions of fecal and TSS.

Table 63. Best Management Practices for Fecal Coliform Bacteria, TSS, and Nutrient Problems

BMP	Fecal	TSS	Nutrients	Potential Reduction
(1) Feedlot Runoff Containment	X		X	High
(2) Manure Management	X		X	High
(3) Grazing Management	X	X	X	Moderate
(4) Alternative Livestock Watering	X	X	X	Moderate
(5) Contour Farming		X	X	Moderate
(6) Contour Strip Farming		X	X	High
(7) Terracing		X	X	High
(8) Conservation Tillage (30% residue)		X	X	Moderate
(9) No Till		X	X	High
(10) Grassed Waterways		X	X	Moderate
(11) Buffer/Filter Strips	X	X	X	Moderate
(12) Commercial Fertilizer Management		X	X	Moderate
(13) Streambank Stabilization		X	X	High
(14) Urban Runoff Controls				
(14a) Pet Waste Control	X		X	High
(14b) Lawn Fertilizer Control			X	High
(14c) Construction Erosion Control		X	X	High
(14d) Street Sweeping		X	X	High
(14e) Stormwater Ponds	X	X	X	High
(15) Wetland Restoration or Creation	X	X	X	High
(16) Riparian Vegetation Restoration	X	X	X	High
(17) Conservation Easements	X	X	X	High
(18) Livestock Exclusion	X	X	X	High

Note: approximate range of reductions:
Low = 0-25% Moderate = 25-75% High = 75-100%

Most of these BMPs are further explained in Table 64 with an explanation of the benefits of using a particular BMP and the reduction that can be achieved when put to use. This table was adapted from an MPCA sources (MPCA 1990).

Table 64. Percent Reduction Achievable by Best Management Practice

BMP	Benefits	Achievable Reduction
Manure Management	• Reduces Nutrient Runoff • Significant Source of Fertilizer	50-100% reduction of nutrient runoff
Buffer/Filter Strips	• Controls sediment, phosphorus, nitrogen, organic matter, and pathogens	50% sediment and nutrient delivery reduction
Conservation Tillage	• Reduces runoff • Reduces wind erosion • More efficient in use of labor, time, fuel, and equipment	30-70% pollutant reduction 50% nutrient loss reduction (depends on residue and direction of rows and contours)
Contouring	• Control erosion of cropland and pasture • Reduces runoff and conserves moisture • Can increase yields	30-50% erosion reduction 25% nutrient reduction 10-50% runoff reduction (based on 2-12 % slope)
Confinement Ponds	• Sediment/nutrient reduction • Reduction in peak flow runoff • Increase in wildlife habitat	60-90% sediment trapping 10-40% nutrient trapping
Fencing	• Reduces erosion • Increases vegetation • Stabilized banks • Improves aquatic habitat	Up to 70% erosion reduction
Grassed Waterways	• Reduces gulleys and channel erosion • Reduces sediment associated nutrient runoff • Increases wildlife habitat	10-50% sediment delivery reduction (broad) 0-10% sediment deliver reduction (narrow)
Strip Cropping	• Reduces erosion and sediment loss • Reduces field loss of sediment associated nutrients	High quality sod strips filter out 75% of eroded soil from cultivated strips
Terraces with Contours	• High reduction of erosion • Reduces loss of sediment associated nutrients	50-100% sediment reduction 25-45% nutrient reduction (2-12 degree slopes)

TSS BMP RECOMMENDATIONS BY PRIORITY AREA

Selection of the BMPs for TSS reduction in the following priority areas is based on predicted reductions from the SDM and a range of potential reductions from Tables 63 and 64. A combination of BMPs from this table could be applied to the following priority areas to achieve the TSS reductions (See Appendix Z for Sediment Yields based on Landuse Scenarios).

Priority Areas R13, GG, HH

Probable sources of TSS in this area may be related to urban construction, storm water runoff, cropland erosion, and streambed and bank erosion. A 72 percent reduction in TSS is needed for this priority area. According to the SDM, if stream buffering, in combination with no till, were applied a 26-70 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area T31

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. A 62 percent reduction in TSS is needed for this priority area. According to the SDM, if stream buffers, contour farming, no-till or conservation tillage, were applied a 34 to 74 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area R01

The North-Central Big Sioux River Watershed Assessment Project will determine the recommendations to meet the goals of R01. A 10 percent reduction is needed for this priority area.

Priority Area R09

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. An 11 percent reduction in TSS is needed for this priority area. According to the SDM, if a combination of conservation tillage, no-till, stream buffers, and contour buffering were applied a 15 to 73 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area R11

Probable sources of TSS in this area may be related to urban runoff, construction site erosion and streambank erosion. A 22 percent reduction in TSS is needed for this priority area. Since this priority area falls within an urban setting, using BMP 13, 14c, 14d, 14e, 15 and 16 from Table 63, would be more beneficial than using the SDM predictions.

Priority Area T33

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. A 20 percent reduction in TSS is needed for this priority area. According to the SDM, if stream buffers, contour farming, no-till and/or conservation tillage, were applied a 28 to 72 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area T27

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. A 43 percent (at 263 mg/L) or a 66 percent (at 158 mg/L) reduction in TSS is needed for this priority area. According to the SDM, if a combination of stream buffers, contour farming, no-till, and/or conservation tillage, were applied a 37 to 71 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area R12

Probable sources of TSS in this area may be related to urban runoff, streambank erosion, cropland erosion, and construction site erosion problems. A 30 percent reduction in TSS is needed for this priority area. According to the SDM for the agricultural land, if stream buffers, contour farming, no-till, and/or conservation tillage, were applied a 44 to 73 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area R03

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. A 17 percent reduction in TSS is needed for this priority area. According to the SDM, if a combination of no-till and stream buffering were applied a 69-73 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area T23

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. This area included T21 which requires a 10 percent reduction in TSS. According to the SDM, if a combination of stream buffering and no-till were applied a 20 to 73 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area T22

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. A 16 percent (at 263 mg/L) or a 50 percent (at 158 mg/L) reduction in TSS is needed for this priority area. According to the SDM, if a combination of stream buffering, no till, and contouring were applied a 41 to 66 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area T19

Probable sources of TSS in this area may be related to streambank erosion, cropland erosion, and construction site erosion problems. A zero percent (at 263 mg/L) or a 36 percent (at 158 mg/L) reduction in TSS is needed for this priority area. According to the SDM, if a combination of stream buffering, no till, and contouring were applied a 28 to 72 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Area T25

Probable sources of TSS in this area may be related to streambank erosion, construction site erosion, and cropland erosion problems. A 17 percent (at 263 mg/L) or a 50 percent (at 158 mg/L) reduction in TSS is needed for this priority area. According to the SDM, if a combination of stream buffering, no till, and contouring were applied a 34 to 74 percent reduction in TSS could be achieved. However, a combination of BMPs from Table 63 should be applied to achieve the overall reduction needed.

Priority Areas T12, T30, and T32

Probable sources of TSS in this area may be related to streambank erosion, construction site erosion, and cropland erosion problems. The watershed areas of Sites T12, T30, and T32 located within Minnesota. Therefore, state and local agencies will need to work with Minnesota on achieving reductions.

FECAL COLIFORM BACTERIA BMP RECOMMENDATIONS BY HYDROLOGIC CONDITION AND PRIORITY AREA

The options necessary to meet the goals of beneficial use (7) from R08-R13 include 1) ensuring the proposed TMDLs will meet the goals, 2) if there are still fecal coliform exceedences after implementing BMPs, then beneficial use (7) may need to be assigned to upstream segments of the Big Sioux River, and/or 3) ensuring the tributaries within the watershed are supporting the goals of the Big Sioux River and if they are not then an evaluation of their standards will be necessary.

The NPDES facility of the City of Hartford was noted as having excessively high daily max concentrations. It is recommended that the facility be assigned a daily max limit that would coincide with the recommendation of assigning beneficial use (7).

Table 65 breaks down the five hydrologic conditions and the possible sources of fecal coliform bacteria and the recommended management practices to help reduce loads. High flow is representative of conditions when precipitation intensity exceeds the rate of water infiltration into the soil, and which may eventually cause flooding. Moist conditions are representative of those periods when the soils are already saturated and where runoff is occurring. Mid-range flows are representative of subsequent rain events, and of a time when saturation is beginning to lessen. Dry conditions are representative of those times when rain is sparse, although may still occur. Low flows are representative of conditions when rain is absent and when there is a drought or drought-like situation.

Table 65. Recommended Management Practices for Fecal Coliform Bacteria Reduction by Hydrological Condition

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
High Flows (0-10)	*Nonpoint Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Sewer System Overflows/Stormwater	**Sewer and NPDES Inspection**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
Moist Conditions (10-40)	*Nonpoint Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Incorrect Land Application of Livestock waste	**Fertilizer Management**
		Livestock In-stream	**Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
		Pastured Livestock	**Fencing, Channel crossing, Grazing Management**
		Sewer System Overflows/Stormwater	**Sewer and NPDES Inspection**
		Urban Runoff	**Pet Waste Management**

Table 65 continued

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
Mid-range Flows (40-60)	*Nonpoint Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Incorrect Land Application of Livestock Waste	**Fertilizer Management**
		Livestock In-Stream	**Fencing, Channel crossing, Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots Pastured Livestock	**Feedlot Runoff Containment Grazing Management**
		Urban Runoff	**Pet Waste Management**
Dry Conditions (60-90)	*Nonpoint/Point Source*	**Absent/Poor Riparian Areas**	**Riparian buffers**- riparian forest buffers, filter strips, grassed waterways, shelterbelts, field windbreaks, living snow fences, contour grass strips, wetland restoration
		Discharge from Wastewater Treatment Plants or Industries	**Point Source Inspection**
		Incorrect Land Application of Livestock Waste	**Fertilizer Management**
		Livestock In-Stream	**Fencing, Channel Crossing, Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
		Pastured Livestock	**Grazing Management**
		Septic System Failure	**Septic System Inspection**

Table 65 continued

Hydrologic Condition	Source of Pollutant	Possible Contributing Source Areas	Recommended Management Practices
Low Flows (90-100)	*Point Source*	**Discharge from Wastewater Treatment Plants or Industries**	**Point Source Inspection**
		Livestock In-Stream	**Fencing, Channel Crossing, Alternative Livestock Watering**
		Manure Runoff/Concentrated Feedlots	**Feedlot Runoff Containment**
		Pastured Livestock	**Grazing Management**
		Septic System Failure	**Septic System Inspection**
		Straight-Pipe Septic Systems	**Septic System Replacement**

Furthermore, BMPs for fecal coliform bacteria reduction can be found on the BMP table (See Table 63). A combination of BMPs from this table could be applied to achieve the fecal coliform bacteria reductions with the exception of 5-10, 12, 13, 14b, 14c, and 14d (See Appendix BB for fecal coliform bacteria loadings and reductions). Monitoring locations requiring immediate attention within each hydrologic condition is discussed.

High Flows

Probable sources of fecal coliform bacteria within the high flows hydrologic condition may be related to absent or poor riparian areas, stormwater runoff, feedlot runoff, and overflowing sewer systems (See Table 65). All sites requiring immediate attention (95-100 percent reductions) are affected by runoff events. Therefore the applicable BMPs for these areas may be 1, 2, 11, 14e, 15, 16, and 17 (See Table 63). Two-thirds of the sites in the very poor category (75-94 percent reduction) were affected only by runoff; whereas, the other one-third was affected by both rain and non-rain periods. Sites R10, R11, and T05 are likely affected by urban runoff; thus, 14a and 14e may be an option. The remaining categories are affected by rain events.

Moist Conditions

Probable sources of fecal coliform bacteria within the moist conditions hydrologic condition may be related to absent or poor riparian areas, stormwater runoff, overflowing sewer systems, urban runoff, incorrect land application of livestock waste, in-stream livestock, pastured livestock, and concentrated feedlots (See Table 65). All sites requiring immediate attention (95-100 percent reductions) are affected by runoff events. The applicable BMPs for these areas may be 1, 2, 3, 4, 11, 15, 16, 17 and 18 (See Table 63). All sites in the very poor category (75-94 percent reduction) are affected by runoff, with sites T15, T28, T29, and T31 also being affected by non-rain periods. The remaining categories are affected by both rain and non-rain periods.

Mid-Range Flows

Probable sources of fecal coliform bacteria within the mid-range flows hydrologic condition may be related to absent or poor riparian areas, urban runoff, incorrect land application of livestock waste, in-stream livestock, pastured livestock, and concentrated feedlots (See Table 65). Site T30 is the only site requiring immediate attention (95-100 percent reductions) and is affected by rain and non-rain periods. The applicable BMPs for this area may be 1, 2, 3, 4, 11, 16, 17 and 18 (See Table 63). Site T27 in the very poor category (75-94 percent reduction) is affected by non-rain periods only, while Site T28 is affected by both rain and non-rain periods. Fencing, channel crossing, alternative livestock watering, and grazing management are recommended for those sites affected by non-rain periods. The remaining categories are mostly affected by non-rain periods, but do include some affects from rain periods.

Dry Conditions

Probable sources of fecal coliform bacteria within the dry conditions hydrologic condition may be related to absent or poor riparian areas, incorrect land application of livestock waste, in-stream livestock, pastured livestock, concentrated feedlots, discharge from wastewater treatment plants, and septic system failure (See Table 65). Site T18 is the only site requiring immediate attention (95-100 percent reductions) and is affected by non-rain periods. The applicable BMPs for this area may be 2, 3, 4, and 18 (See Table 63). All sites in the very poor category (75-94 percent reduction) were affected by non-rain periods. This may indicate discharge problems and in-stream livestock. Fencing, channel crossing, alternative livestock watering, and grazing management are recommended for those sites affected by non-rain periods. The remaining categories are affected mainly by non-rain periods. A combination of BMPs from Table 63 should be applied to achieve the needed reductions.

Low Flows

Probable sources of fecal coliform bacteria within the low flow hydrologic condition may be related to in-stream livestock, concentrated feedlots, discharge from wastewater treatment plants, straight pipes, and septic system failure (See Table 65). The applicable BMPs for this area may be 2, 3, 4, and 18 (See Table 63). All sites in all categories are affected by non-rain periods. This may indicate problems with industrial discharge, septic leakage, and in-stream livestock. Fencing, channel crossing, alternative livestock watering, and grazing management are recommended for those sites affected by non-rain periods.

PUBLIC INVOLVEMENT AND COORDINATION

STATE AGENCIES

The SD DENR was the primary state agency involved in the completion of this assessment. They provided equipment as well as technical assistance throughout the project. They also provided ambient water quality data for several of the Big Sioux River sites.

FEDERAL AGENCIES

The Environmental Protection Agency (EPA) provided the primary source of funds for the completion of the assessment of the Big Sioux River watershed.

The United States Geological Survey (USGS) provided historical stream flow data for the watershed. Sample data collected by USGS was also used in the final report for the assessment.

The Natural Resource Conservation Service (NRCS) provided technical assistance

TMDLs that include tributaries that drain land in Minnesota will require future coordination with EPA Region 5.

LOCAL GOVERNMENTS, OTHER GROUPS, AND GENERAL PUBLIC

The EDWDD provided the sponsorship that made this project possible on a local basis. In addition to providing administrative sponsorship, EDWDD also provided local matching funds and personnel to complete the assessment.

Public involvement consisted of individual meetings with landowners that provided a great deal of historic perspective on the watershed.

The SD DENR and EDWDD have initiated contact with MPCA concerning pollution reductions for those tributaries that drain land in Minnesota and require a TMDL.

OTHER SOURCES OF FUNDS

In addition to funds supplied by the East Dakota Water Development District (EDWDD) and the Environmental Protection Agency (EPA), additional financial support was provided by the Brookings County Conservation District (BCCD) and the South Dakota Conservation Commission (through a grant to BCCD). The inventory of the animal feeding operations and assessment of the potential environmental risk posed by each was work completed by BCCD using these funds in support of the overall project. The inventory and assessment of the AFOs was funded by EPA 319, EDWDD, and the SDCC grant.

ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

Most of the objectives proposed for the project were met in an acceptable fashion and in a reasonable time frame. Watershed modeling and QA/QC was behind schedule due to delays of several months in receiving water quality results. With such an vast number of sampling sites to evaluate and analyze, any sort of delay was compounded by more delays in other areas. In addition, another sizeable 319 funded watershed assessment project began before completion of this project, further delaying the completion of the assessment report for this project.

There was difficulty during the data analysis portion due to half of the BSR and tributary sites being monitored from 1999-2000 and the other half of the BSR and tributary sites being monitored from 2000-2001. It would have been easier to compare and contrast information if sampling had occurred during the same months for all years.

The fish and macroinvertebrate sampling would have told us more if we could have sampled during each year of the project or at least twice in the one year it was done. Macroinvertebrates weren't collected until mid-October making it difficult to compare bugs with the fecal coliform data, as the standards only apply during May through September.

Rock baskets may be misleading to the types of macroinvertebrates inhabiting a stream at a particular site. It would only be valuable if the substrate of that stream included rocks. A rock basket within a silt-bottom stream may collect bugs that are not typically seen or inhabit that area of the stream due to rocks not ordinarily being in the area. Possibly another method of sampling macroinvertebrates in these heavily silted streams would be more effective (i.e. kick net).

Not being able to use a geo-mean for fecal coliform bacteria made it very difficult to compute reductions. Much time was wasted trying to determine an acceptable method for computing fecal coliform bacteria reductions with the limited amount of grab sample data. More grab samples should have been taken over the course of the project so that a geo-mean calculation could have been used.

Sampling and analysis methods could be improved in future projects by

- coordinating macroinvertebrate, fish, and water sampling
- sampling more than once for fishes and macroinvertebrates through the project period
- determining if rock baskets are adequate for sampling sites with a bed substrate of silt or clay
- separating and analyzing the data by subwatershed level or by stream order
- increasing the number of instantaneous discharge measurements at ungaged sites
- having reference sites to compare data to

Overall, taking into consideration the size of this project, things went as well as or better than expected.

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Appendix A.
Monitoring Site Locations

CBSRWAP Water Quality Sampling Sites			
Site ID	**Descriptive Name**	**Latitude**	**Longitude**
R01	BSR nr Brookings	44 17 50	096 52 04
R02	BSR at Sinai Road	44 15 15	096 50 00
R03	BSR at Hwy 77	44 11 50	096 47 20
R04	BSR at USGS Brookings	44 10 50	096 44 55
R05	BSR nr Flandreau	44 04 30	096 35 15
R06	BSR at Egan	44 00 30	096 37 45
R07	BSR at Trent	43 54 20	096 39 45
R08	BSR at USGS Dell Rapids	43 47 25	096 44 42
R09	BSR at Hwy 38A	43 36 35	096 44 39
R10	BSR at Western Ave.	43 30 05	096 44 55
R11	BSR at USGS N.Cliff Ave.	43 34 01	096 42 39
R12	BSR at Brandon	43 35 41	096 35 59
R13	BSR nr Gitchie Manitou	43 29 30	096 35 10
T01	No Deer Ck (upper) nr Bruce	44 27 45	096 47 20
T02	No Deer Ck (lower) at Brookings	44 17 50	096 50 45
T03	Six Mile Ck (upper) at White	44 26 30	096 38 45
T04	Six Mile Ck (middle) above Brookings	44 21 00	096 44 50
T05	Six Mile Ck (lower) below Brookings	44 17 50	096 50 00
T06	Deer Creek at Brookings	44 18 45	096 43 15
T07	Medary Ck (upper) at Elkton	44 15 30	096 29 15
T08	Medary Ck (middle) nr Aurora	44 17 00	096 38 45
T09	Medary Ck (lower) nr Brookings	44 13 30	096 46 00
T10	Lake Campbell Outlet	44 13 30	096 50 30
T11	Spring Creek nr Flandreau	44 07 05	096 35 20
T12	Flandreau Creek nr Flandreau	44 03 45	096 29 00
T13	Jack Moore Creek nr Egan	43 59 20	096 39 00
T14	Bachelor Creek nr Trent	43 55 30	096 42 30
T15	North Buffalo Creek nr Chester	43 54 25	096 58 50
T16	Buffalo Creek nr Chester	43 52 20	096 55 45
T17	Brant Lake Outlet	43 55 10	096 57 45
T18	Skunk Ck (upper) nr Chester	43 50 53	096 50 10
T19	Colton Creek nr Hartford	43 41 45	096 54 45
T20	W. Branch Skunk Ck nr Hartford	43 40 03	096 55 47
T21	Skunk Ck (middle) nr Sioux Falls	43 34 20	096 52 35
T22	Willow Creek nr Sioux Falls	43 33 30	096 49 30
T23	Skunk Creek (lower) at Sioux Falls	43 32 01	096 47 26
T24	Silver Creek nr Renner	43 37 50	096 43 10
T25	Slip-up Creek nr Renner	43 37 15	096 40 15
T26	W Pipestone Ck (upper) nr Sherman	43 47 15	096 34 45
T27	W Pipestone Ck (lower) nr Corson	43 38 10	096 34 15
T28	Pipestone Ck (upper) nr Egan	43 58 00	096 27 50
T29	Pipestone Ck (lower) nr Sherman	43 48 45	096 28 15
T30	Split Rock Ck (upper) nr Sherman	43 15 45	096 27 10
T31	Split Rock Ck (lower) nr Corson	43 36 59	096 33 54
T32	Beaver Ck (upper) nr Valley Springs	43 35 30	096 27 00
T33	Beaver Ck (lower) nr Brandon	43 33 30	096 34 50

Appendix B.
WQ Grab Sample Data

Site	Stream	Date	Time	Lab#	Wtemp	Cond	Spec Cond	Salinity	DO	pH	NTU	Fecal	Sups Sol	Tot Sol	Dis Sol	NO2 NO3	NH3N	Org Ntr	TKN	Tot PO4	TD PO4
R01	BSR nr Brookings	06/02/00	830	00-6117	14.0	833	1055	0.5	7.0	8.43	60	500	140	992	852	0.07	0.12	2.21	2.33	0.46	0.04
R01	BSR nr Brookings	06/28/00	1000	00-6175	18.4	763	894	0.5	7.5	8.37	90	80	208	848	640	0.07	0.16	2.74	2.90	0.50	0.05
R01	BSR nr Brookings	07/14/00	1000	00-6245	25.5	834	-----	0.4	5.2	8.03	116	300	314	886	572	0.12	0.10	3.35	3.45	0.65	0.05
R01	BSR nr Brookings	10/27/00	1515	-----	16.1	987	-----	------	15.0	7.00	-----	------	23	-----	-----	-----	0.02	-----	1.36	0.11	0.01
R01	BSR nr Brookings	11/02/00	930	00-6416	8.1	672	993	0.5	9.5	8.08	30	3600	61	713	652	0.12	0.12	1.69	1.82	0.40	0.05
R02	BSR at Sinai Road	07/27/99	1745	99-6013	29.3	1075	-----	0.5	8.0	8.41	100	40	203	1007	804	0.01	0.06	2.69	2.75	0.36	0.05
R02	BSR at Sinai Road	08/09/99	930	99-6033	23.3	1046	-----	0.5	6.0	8.65	75	220	175	929	754	0.09	0.10	2.50	2.60	0.36	0.03
R02	BSR at Sinai Road	09/14/99	1015	99-6055	12.3	1030	-----	0.5	9.2	8.71	39	130	100	896	796	0.32	0.05	2.17	2.22	0.25	0.04
R02	BSR at Sinai Road	10/12/99	1015	99-6095	11.4	1022	-----	0.5	9.4	8.73	20	30	54	790	736	0.04	0.02	1.85	1.86	0.14	0.03
R02	BSR at Sinai Road	03/12/00	1730	00-6006	2.4	607	1070	0.5	14.9	8.56	20	<1	38	654	616	0.79	0.24	1.28	1.51	0.45	0.27
R02	BSR at Sinai Road	04/10/00	1200	00-6027	7.2	652	986	0.5	10.7	8.59	25	20	63	763	700	0.21	0.02	1.45	1.47	0.23	0.02
R02	BSR at Sinai Road	05/09/00	925	00-6059	13.1	695	899	0.4	8.1	8.35	45	300	126	842	716	0.03	0.10	2.35	2.46	0.39	0.02
R02	BSR at Sinai Road	05/19/00	900	00-6094	12.5	518	680	0.3	7.5	8.45	130	6800	195	615	420	0.55	0.19	1.93	2.12	0.59	0.19
R02	BSR at Sinai Road	06/02/00	845	00-6118	14.6	777	969	0.5	7.7	8.17	70	700	188	916	728	0.10	0.13	2.11	2.23	0.52	0.09
R02	BSR at Sinai Road	06/13/00	1110	00-6158	21.8	1004	1070	0.5	6.3	8.15	85	600	213	905	692	0.18	0.08	2.27	2.35	0.50	0.05
R02	BSR at Sinai Road	07/14/00	1020	00-6246	26.1	744	728	0.4	6.3	7.97	119	1000	196	760	564	0.08	0.13	2.93	3.06	0.65	0.12
R02	BSR at Sinai Road	08/17/00	930	00-6303	18.1	763	879	0.4	6.8	7.98	28	310	54	646	592	0.06	0.10	2.13	2.22	0.33	0.06
R02	BSR at Sinai Road	09/06/00	1010	00-6325	16.6	713	850	0.4	6.1	8.29	43	200	95	651	556	0.05	0.04	1.64	1.68	0.31	0.05
R02	BSR at Sinai Road	10/18/00	945	00-6383	9.2	621	933	0.4	5.6	8.19	44	120	62	622	560	0.04	0.04	1.50	1.54	0.24	0.06
R02	BSR at Sinai Road	11/02/00	1030	00-6418	8.7	598	868	0.4	7.1	8.04	49	1500	85	657	572	0.13	0.04	1.70	1.75	0.37	0.05
R03	BSR at Hwy 77	06/02/00	915	00-6119	15.0	874	1081	0.5	7.4	7.96	60	400	174	946	772	0.28	0.13	2.03	2.17	0.51	0.13
R03	BSR at Hwy 77	06/28/00	1400	00-6185	22.2	750	793	0.4	8.3	8.39	100	60	248	844	596	0.41	0.12	2.48	2.60	0.60	0.13
R03	BSR at Hwy 77	07/14/00	1100	00-6247	26.5	698	680	0.3	5.1	8.49	113	300	326	930	604	0.22	0.13	3.00	3.13	0.68	0.14
R03	BSR at Hwy 77	08/17/00	1000	00-6304	18.3	834	955	0.5	7.9	7.79	27	320	44	784	740	1.40	0.06	2.16	2.22	0.62	0.30
R03	BSR-Hwy 77	10/27/00	1450	-----	17.9	993	-----	------	15.9	6.92	-----	------	45	780	735	0.70	0.02	-----	1.54	0.23	0.01
R03	BSR at Hwy 77	11/02/00	1100	00-6419	8.6	597	870	0.4	10.0	7.94	66	1300	131	687	556	1.39	0.11	1.81	1.91	0.69	0.20
R04	BSR at USGS Brookings	07/27/99	1715	99-6014	29.7	1068	-----	0.5	8.2	8.32	110	600	168	968	800	0.01	0.05	2.31	2.36	0.39	0.06
R04	BSR at USGS Brookings	08/10/99	1015	99-6034	24.1	1031	-----	0.5	6.7	8.56	75	130	166	1074	908	0.06	0.08	2.71	2.79	0.38	0.03
R04	BSR at USGS Brookings	09/14/99	1100	99-6056	12.8	1052	-----	0.5	9.7	8.71	38	170	91	855	764	0.65	0.05	2.12	2.16	0.32	0.11
R04	BSR at USGS Brookings	10/12/99	1415	99-6096	13.1	1018	-----	0.5	11.7	8.70	21	20	48	700	652	0.35	0.03	1.93	1.96	0.25	0.02
R04	BSR at USGS Brookings	03/13/00	1100	00-6010	1.4	599	-----	0.5	13.3	8.53	14	<1	33	695	662	1.23	0.12	1.45	1.57	0.44	0.29
R04	BSR at USGS Brookings	04/10/00	1000	00-6023	7.6	688	1031	0.5	10.1	8.65	31	<10	70	822	752	0.83	0.05	1.30	1.35	0.30	0.11
R04	BSR at USGS Brookings	05/09/00	1030	00-6061	13.8	693	882	0.4	8.7	8.23	55	280	133	753	620	0.53	0.03	2.15	2.18	0.47	0.06
R04	BSR at USGS Brookings	05/19/00	1015	00-6097	12.7	535	699	0.3	7.0	7.96	170	20000	299	704	405	0.68	0.20	2.20	2.39	0.72	0.16
R04	BSR at USGS Brookings	06/02/00	930	00-6120	15.3	710	873	0.4	7.0	7.92	70	300	184	824	640	0.45	0.11	1.91	2.02	0.52	0.14
R04	BSR at USGS Brookings	06/14/00	900	00-6149	18.0	914	1054	0.5	7.2	8.23	50	310	115	915	800	0.57	0.08	1.80	1.87	0.38	0.09
R04	BSR at USGS Brookings	07/14/00	1130	00-6248	26.7	737	714	0.3	5.1	7.24	136	400	260	796	536	0.29	0.19	3.39	3.58	0.67	0.14
R04	BSR at USGS Brookings	08/17/00	1030	00-6305	18.4	816	932	0.5	8.7	7.96	24	600	48	672	624	1.16	0.06	1.91	1.97	0.52	0.22
R04	BSR at USGS Brookings	09/06/00	1040	00-6326	17.0	666	902	0.4	11.3	8.54	30	600	65	633	568	1.01	0.08	2.24	2.31	0.59	0.19

R04	BSR at USGS Brookings	10/18/00	1000	00-6384	9.3	689	985	0.5	10.3	8.61	33	240	60	680	620	1.24	0.06	1.98	2.04	0.72	0.03
R04	BSR at USGS Brookings	11/02/00	1130	00-6420	9.1	511	734	0.4	9.7	7.95	62	1200	88	556	468	1.30	0.11	1.66	1.78	0.57	0.15
R05	BSR nr Flandreau	07/27/99	1245	99-6015	27.1	1035	-----	0.5	7.3	8.19	70	<100	100	776	676	0.31	0.03	1.90	1.93	0.27	0.09
R05	BSR nr Flandreau	08/10/99	1215	99-6035	25.3	1032	-----	0.5	7.3	8.71	55	110	112	956	844	0.06	0.06	2.38	2.44	0.32	0.03
R05	BSR nr Flandreau	09/13/99	1330	99-6057	14.8	1014	-----	0.5	5.8	8.86	55	50	90	822	732	0.27	0.04	2.35	2.39	0.33	0.07
R05	BSR nr Flandreau	10/12/99	1600	99-6097	13.0	958	-----	0.5	11.7	8.82	32	30	36	660	624	0.05	0.03	1.64	1.67	0.18	0.04
R05	BSR nr Flandreau	03/13/00	1440	00-6017	3.2	593	1019	0.5	14.1	8.53	12	<1	20	680	660	1.30	0.01	1.10	1.11	0.36	0.22
R05	BSR nr Flandreau	04/11/00	1015	00-6037	5.9	631	994	0.5	11.4	8.75	21	20	43	687	644	0.63	0.02	1.57	1.58	0.25	0.04
R05	BSR nr Flandreau	05/09/00	1045	00-6062	14.3	665	835	0.4	8.6	8.42	45	190	69	677	608	0.44	0.06	2.02	2.08	0.33	0.03
R05	BSR nr Flandreau	05/19/00	1100	00-6099	13.3	500	643	0.3	7.4	7.90	260	15000	444	884	440	0.79	0.29	2.69	2.98	0.97	0.16
R05	BSR nr Flandreau	06/02/00	1015	00-6121	16.2	661	795	0.4	7.4	7.90	70	200	190	746	556	0.52	0.16	1.90	2.06	0.52	0.16
R05	BSR nr Flandreau	07/14/00	1215	00-6249	27.4	765	732	0.4	5.9	7.86	84	200	147	715	568	0.28	0.16	2.39	2.55	0.44	0.10
R05	BSR nr Flandreau	08/17/00	1100	00-6306	18.7	747	850	0.4	6.3	8.16	46	390	120	704	584	0.06	0.09	2.40	2.50	0.43	0.10
R05	BSR nr Flandreau	09/06/00	1200	00-6329	19.0	691	779	0.4	8.5	8.34	83	100	116	600	484	0.04	0.12	2.71	2.83	0.48	0.03
R05	BSR nr Flandreau	10/18/00	1030	00-6385	10.5	596	825	0.4	14.9	8.72	55	90	68	588	520	0.07	0.07	2.62	2.69	0.61	0.05
R06	BSR at Egan	07/27/99	1345	99-6016	28.8	1031	-----	0.5	8.4	8.19	95	120	138	754	616	0.36	0.01	2.04	2.05	0.33	0.09
R06	BSR at Egan	08/10/99	1245	99-6036	26.4	1032	-----	0.5	8.0	8.64	90	100	142	950	808	0.09	0.13	2.40	2.53	0.34	0.05
R06	BSR at Egan	09/14/99	1200	99-6058	13.8	1009	-----	0.5	10.1	8.94	50	40	88	800	712	0.25	0.09	2.40	2.49	0.32	0.05
R06	BSR at Egan	10/12/99	1830	99-6098	13.3	954	-----	0.5	12.0	8.93	40	50	75	651	576	0.11	0.03	1.77	1.80	0.22	0.04
R06	BSR at Egan	03/14/00	745	00-6019	2.1	545	972	0.5	11.5	8.61	11	2	20	648	628	0.96	0.02	1.27	1.29	0.26	0.10
R06	BSR at Egan	04/11/00	1100	00-6039	7.2	591	896	0.4	13.1	8.81	37	-----	73	649	576	0.05	0.02	2.02	2.04	0.25	0.01
R06	BSR at Egan	05/09/00	1115	00-6063	16.2	707	849	0.4	8.6	8.40	45	390	95	699	604	0.05	0.05	1.64	1.69	0.28	0.02
R06	BSR at Egan	05/19/00	1200	00-6101	14.2	543	685	0.3	7.4	8.04	110	2500	190	578	388	0.82	0.18	2.07	2.25	0.50	0.15
R06	BSR at Egan	06/02/00	1030	00-6122	16.9	584	692	0.3	6.7	7.87	120	500	220	684	464	0.63	0.20	1.86	2.06	0.52	0.18
R06	BSR at Egan	06/14/00	1100	00-6152	19.8	916	1015	0.5	6.7	8.42	60	210	110	786	676	0.31	0.21	2.22	2.43	0.37	0.11
R06	BSR at Egan	07/14/00	1315	00-6250	29.2	702	650	0.3	7.5	7.44	90	400	168	596	428	0.37	0.12	2.46	2.58	0.38	0.08
R06	BSR at Egan	08/17/00	1130	00-6307	20.7	698	761	0.4	8.5	7.89	29	8500	44	600	556	0.36	0.34	1.63	1.96	0.32	0.07
R06	BSR at Egan	09/06/00	1245	00-6330	19.9	518	574	0.3	9.4	8.27	34	400	68	624	556	0.05	0.09	2.17	2.26	0.34	0.02
R06	BSR at Egan	10/18/00	1050	00-6386	9.6	580	823	0.4	10.8	8.50	34	50	36	540	504	0.04	0.12	2.11	2.23	0.36	0.04
R07	BSR at Trent	07/27/99	1500	99-6017	28.7	1056	-----	0.5	8.3	8.22	100	90	180	916	736	0.46	0.02	1.91	1.93	0.35	0.10
R07	BSR at Trent	08/10/99	1430	99-6037	26.8	1036	-----	0.5	9.4	8.80	85	50	152	976	824	0.06	0.09	2.54	2.63	0.35	0.05
R07	BSR at Trent	09/14/99	1230	99-6059	14.2	999	-----	0.5	10.7	8.98	60	140	105	817	712	0.08	0.05	2.58	2.63	0.33	0.04
R07	BSR at Trent	10/12/99	1715	99-6099	14.1	951	-----	0.5	11.7	8.98	45	30	53	681	628	0.05	0.02	1.80	1.81	0.21	0.05
R07	BSR at Trent	03/14/00	830	00-6020	2.9	546	947	0.5	12.3	8.73	14	<1	30	666	636	0.55	0.01	1.68	1.69	0.25	0.03
R07	BSR at Trent	04/11/00	1230	00-6042	7.7	589	880	0.4	13.5	8.78	36	10	79	657	578	0.05	0.04	1.88	1.92	0.25	0.26
R07	BSR at Trent	05/09/00	1145	00-6064	15.6	655	799	0.4	9.7	8.45	35	4000	75	687	612	0.24	0.06	1.63	1.69	0.27	0.03
R07	BSR at Trent	05/19/00	1300	00-6104	14.4	648	814	0.4	8.2	8.21	95	17000	240	816	576	1.28	0.16	2.40	2.57	0.59	0.15
R07	BSR at Trent	06/02/00	1100	00-6123	16.9	603	715	0.4	7.3	7.84	120	300	270	754	484	0.76	0.20	1.95	2.15	0.61	0.13
R07	BSR at Trent	06/13/00	1230	00-6144	21.3	979	1014	0.5	6.7	8.48	71	190	141	877	736	0.06	0.06	2.16	2.22	0.38	0.03
R07	BSR at Trent	06/14/00	1245	00-6168	19.0	869	975	0.5	8.9	8.56	55	100	109	793	684	0.30	0.10	2.10	2.20	0.34	0.02
R07	BSR at Trent	07/14/00	1400	00-6251	28.5	819	768	0.4	7.6	7.76	77	200	145	673	528	0.21	0.08	2.42	2.49	0.38	0.09
R07	BSR at Trent	08/17/00	1200	00-6308	19.8	710	792	0.4	9.2	8.31	31	1800	84	668	584	0.05	0.06	2.17	2.22	0.37	0.06

R07	BSR at Trent	09/06/00	1330	00-6331	19.1	714	806	0.4	10.8	8.22	44	400	94	610	516	0.03	0.10	2.17	2.27	0.31	0.03
R07	BSR at Trent	10/18/00	1115	00-6387	11.0	579	795	0.4	9.1	8.61	63	60	78	558	480	0.05	0.07	2.27	2.35	0.33	0.04
R08	BSR at USGS Dell Rapids	07/11/00	1100	00-6205	27.6	843	804	0.4	6.8	7.25	73	1700	110	714	604	0.06	0.04	2.60	2.64	0.44	0.06
R08	BSR at USGS Dell Rapids	08/17/00	1215	00-6309	21.7	710	799	0.4	7.8	8.04	44	570	86	634	548	0.06	0.06	2.24	2.30	0.34	0.05
R08	BSR at USGS Dell Rapids	09/20/00	1000	00-6353	14.3	660	830	0.4	6.1	7.95	46	100	78	658	580	0.13	0.16	2.23	2.39	0.35	0.02
R08	BSR at USGS Dell Rapids	10/18/00	1140	00-6388	11.6	639	869	0.4	9.1	8.42	40	90	40	584	544	0.21	0.15	1.44	1.59	0.20	0.05
R08	BSR at USGS Dell Rapids	04/04/01	945	01-6034	0.4	170	-----	0.1	9.7	8.47	172	180	474	742	268	1.44	0.96	2.57	3.53	0.99	0.40
R08	BSR at USGS Dell Rapids	04/12/01	800	01-6056	7.5	292	440	0.2	7.0	8.02	40	1800	93	448	355	1.68	0.43	1.67	2.10	0.56	0.36
R08	BSR at USGS Dell Rapids	04/24/01	1000	01-6107	5.7	288	463	0.2	10.1	7.97	125	7900	134	409	275	1.25	0.24	1.56	1.80	0.57	0.27
R08	BSR at USGS Dell Rapids	05/08/01	1145	01-6162	14.8	636	809	0.4	8.7	7.72	15	400	26	606	580	0.47	0.11	1.10	1.21	0.23	0.16
R08	BSR at USGS Dell Rapids	06/06/01	1000	01-6196	16.4	843	1006	0.5	12.5	8.31	19	100	49	1301	1252	0.52	0.04	1.12	1.15	0.23	0.13
R08	BSR at USGS Dell Rapids	06/13/01	1030	01-6203	20.4	812	890	0.4	7.2	8.76	109	52000	164	749	585	1.60	0.21	2.31	2.52	0.49	0.17
R08	BSR at USGS Dell Rapids	07/10/01	1045	01-6256	27.2	1064	1024	0.5	4.4	8.08	50	70	112	856	744	0.93	0.13	1.14	1.27	0.17	0.29
R08	BSR at USGS Dell Rapids	07/24/01	1120	01-6270	27.3	1004	961	0.5	10.1	8.14	55	600	136	796	660	1.25	0.12	1.42	1.54	0.44	0.21
R08	BSR at USGS Dell Rapids	08/14/01	1030	01-6937	23.3	1021	1055	0.5	7.5	8.63	48	100	95	959	864	0.03	0.07	1.95	2.01	0.38	0.13
R08	BSR at USGS Dell Rapids	09/12/01	915	01-6374	20.0	976	1080	0.5	7.0	8.79	66	110	108	928	820	0.06	0.08	2.35	2.43	0.39	0.09
R08	BSR at USGS Dell Rapids	10/09/01	1115	01-6426	12.1	799	1061	0.5	12.5	8.74	55	100	100	880	780	0.03	0.05	2.36	2.41	0.28	0.02
R09	BSR at Hwy 38A	07/11/00	1130	00-6206	26.6	840	795	0.4	4.9	7.37	58	800	134	686	552	0.09	0.09	2.08	2.18	0.35	0.06
R09	BSR at Hwy 38A	08/16/00	1410	00-6295	21.6	737	789	0.4	5.8	8.02	54	500	106	586	480	0.06	0.03	1.86	1.89	0.35	0.03
R09	BSR at Hwy 38A	09/20/00	1040	00-6354	13.5	681	872	0.4	7.1	8.27	45	290	59	663	604	0.06	0.05	1.54	1.59	0.27	0.06
R09	BSR at Hwy 38A	10/18/00	1200	00-6389	14.2	636	804	0.4	9.2	8.24	23	50	20	500	480	0.06	0.09	1.00	1.09	0.14	0.05
R09	BSR at Hwy 38A	04/04/01	1020	01-6035	0.4	146	------	0.1	9.8	8.3	215	170	496	696	200	1.37	1.00	2.82	3.82	1.20	0.34
R09	BSR at Hwy 38A	04/12/01	1040	01-6063	5.7	281	420	0.2	4.2	7.54	75	1300	214	494	280	1.70	0.51	1.80	2.31	0.68	0.32
R09	BSR at Hwy 38A	04/24/01	1030	01-6108	6.1	290	459	0.2	9.4	7.67	149	15000	122	447	325	1.26	0.26	1.60	1.87	0.61	0.28
R09	BSR at Hwy 38A	05/08/01	1300	01-6163	14.9	651	804	0.4	8.4	7.70	23	1700	76	584	508	0.50	0.10	1.16	1.26	0.28	0.16
R09	BSR at Hwy 38A	06/06/01	1100	01-6197	16.5	843	1006	0.5	11.3	8.36	29	200	140	876	736	0.46	0.02	1.21	1.22	0.34	0.13
R09	BSR at Hwy 38A	06/14/01	1430	01-6918	20.6	591	645	0.3	8.1	7.84	337	31000	368	838	470	3.64	0.31	2.99	3.30	1.00	0.25
R09	BSR at Hwy 38A	07/10/01	1130	01-6257	27.2	1104	1059	0.5	5.0	8.10	52	120	116	820	704	0.88	0.07	1.25	1.31	0.34	0.17
R09	BSR at Hwy 38A	07/24/01	1145	01-6271	26.3	938	915	0.4	10.7	8.22	83	56000	200	872	672	1.29	0.12	1.53	1.65	0.48	0.19
R09	BSR at HWY 38A	08/14/01	1145	01-6938	22.5	1002	1053	0.5	7.6	8.64	59	50	121	949	828	0.04	0.06	1.84	1.90	0.38	0.13
R09	BSR at HWY 38A	09/12/01	1000	01-6375	19.0	965	1090	0.5	7.5	8.64	43	70	80	896	816	0.11	0.04	1.78	1.81	0.32	0.09
R09	BSR at HWY 38A	10/09/01	1030	01-6425	12.0	786	1047	0.5	11.8	8.69	31	100	19	717	698	0.08	0.05	2.03	2.08	0.23	0.03
R10	BSR at Western Ave.	06/12/00	1410	00-6135	24.0	1096	1118	0.6	11.0	8.19	45	130	76	1096	1020	0.04	0.06	2.00	2.06	0.26	0.03
R10	BSR at Western Ave.	07/11/00	1500	00-6210	28.9	1061	988	0.5	13.9	8.23	16	1800	37	813	776	0.07	0.02	1.70	1.72	0.20	0.03
R10	BSR at Western Ave.	08/16/00	1515	00-6298	24.1	1128	1149	0.6	7.7	7.97	20	700	40	828	788	0.16	0.07	1.37	1.44	0.19	0.04
R10	BSR at Western Ave.	09/20/00	1115	00-6355	12.9	899	1170	0.6	10.0	7.86	9	520	8	928	920	0.12	0.02	1.48	1.50	0.11	0.03
R10	BSR at Western Ave.	10/18/00	1320	00-6392	13.7	929	1191	0.6	10.4	8.02	16	320	13	821	808	0.60	0.15	0.70	0.85	0.10	0.03
R10	BSR at Western Ave.	04/04/01	1135	01-6038	5.6	335	532	0.3	5.80	8.12	65	100	167	531	364	1.54	0.64	1.85	2.50	0.69	0.42
R10	BSR at Western Ave.	04/12/01	1245	01-6068	7.1	430	651	0.3	3.1	7.54	83	5800	212	644	432	1.56	0.47	1.92	2.39	0.74	0.36
R10	BSR at Western Ave.	04/24/01	1315	01-6112	7.7	437	657	0.3	9.5	7.82	103	3900	152	582	430	1.59	0.22	1.51	1.73	0.54	0.26
R10	BSR at Western Ave.	05/08/01	1515	01-6166	16.3	806	977	0.4	8.8	7.71	25	900	56	692	636	0.40	0.07	1.18	1.25	0.17	0.26
R10	BSR at Western Ave.	06/05/01	1400	01-6192	16.0	1009	1217	0.6	12.2	8.40	23	<100	59	975	916	0.74	0.09	1.12	1.21	0.24	0.10

R10	BSR at Western Ave.	06/14/01	1600	01-6920	21.4	614	659	0.3	8.2	7.93	173	8000	274	810	536	3.29	0.34	2.65	2.99	0.75	0.35
R10	BSR at Western Ave.	07/10/01	1315	01-6260	26.9	1137	1097	0.5	4.6	8.22	57	190	114	874	760	0.96	0.09	1.62	1.71	0.21	0.16
R10	BSR at Western Ave.	07/24/01	1400	01-6294	23.3	446	463	0.2	11.5	8.27	569	11000	703	1091	388	0.81	0.25	1.93	2.17	1.25	0.13
R10	BSR at Western Ave.	08/13/01	1515	01-6934	25.6	1074	1062	0.5	10.6	8.51	67	<100	144	1000	856	0.05	0.08	2.03	2.11	0.43	0.14
R10	BSR at Western Ave.	09/12/01	1115	01-6378	20.3	1004	1104	0.5	7.7	8.61	48	60	104	944	840	0.06	0.05	1.77	1.82	0.32	0.08
R10	BSR at Western Ave.	10/09/01	915	01-6422	11.7	824	1106	0.6	16.3	8.32	32	100	67	807	740	0.16	0.06	1.83	1.89	0.23	0.02
R11	BSR at USGS N.Cliff Ave.	07/11/00	1230	00-6207	27.6	938	893	0.4	8.2	7.87	38	4000	66	682	616	2.93	0.02	2.09	2.11	0.79	0.59
R11	BSR at USGS N.Cliff Ave.	08/16/00	1445	00-6297	24.4	1146	1159	0.6	9.1	8.05	48	170	80	796	716	5.47	0.14	2.77	2.91	1.30	1.02
R11	BSR at USGS N.Cliff Ave.	09/20/00	1100	00-6356	16.5	1264	1512	0.8	9.1	8.04	23	500	30	1046	1016	10.09	0.19	2.15	2.34	2.70	2.64
R11	BSR at USGS N.Cliff Ave.	10/18/00	1340	00-6393	15.7	998	1215	0.6	10.3	8.91	32	1200	33	817	784	8.84	0.14	2.21	2.34	2.23	1.99
R11	BSR at USGS N.Cliff Ave.	04/04/01	1230	01-6039	3.2	221	381	0.2	7.9	8.05	171	270	386	634	248	1.43	0.92	2.48	3.40	1.07	0.35
R11	BSR at USGS N.Cliff Ave.	04/12/01	1315	01-6071	8.1	354	526	0.3	2.8	7.80	116	3400	255	610	355	1.66	0.46	2.14	2.59	0.73	0.35
R11	BSR at USGS N.Cliff Ave.	04/24/01	1350	01-6113	7.1	351	534	0.3	12.2	7.81	146	8800	144	519	375	1.38	0.26	1.66	1.91	0.61	0.27
R11	BSR at USGS N.Cliff Ave.	05/08/01	1615	01-6167	16.8	768	894	0.4	9.2	7.83	28	1700	70	686	616	0.63	0.10	1.19	1.29	0.29	0.19
R11	BSR at USGS N.Cliff Ave.	06/05/01	1430	01-6193	16.3	912	1093	0.5	13.1	8.40	25	200	64	812	748	1.28	0.09	1.27	1.36	0.33	0.21
R11	BSR at USGS N.Cliff Ave.	06/14/01	1515	01-6919	21.1	687	742	0.4	11.3	8.11	288	31000	333	837	504	3.16	0.23	2.91	3.14	0.71	0.30
R11	BSR at USGS N.Cliff Ave.	07/10/01	1345	01-6261	27.1	1147	1104	0.5	3.7	8.34	63	270	124	890	766	1.92	0.14	1.30	1.44	0.39	0.27
R11	BSR at USGS N.Cliff Ave.	07/24/01	1430	01-6295	24.0	453	467	0.2	13.7	8.16	322	26000	513	861	348	1.07	0.29	1.88	2.17	0.93	0.19
R11	BSR at USGS N.Cliff Ave.	08/14/01	1345	01-6941	23.2	1059	1097	0.5	8.3	8.60	69	800	138	966	828	2.02	0.12	2.16	2.29	0.63	0.32
R11	BSR at USGS N.Cliff Ave.	09/12/01	1130	01-6379	20.8	1116	1214	0.6	8.5	8.70	55	160	129	1005	876	3.36	0.08	2.30	2.38	0.84	0.56
R11	BSR at USGS N.Cliff Ave.	10/09/01	830	01-6421	15.3	624	803	0.4	16.5	8.40	36	50	75	907	832	4.19	0.07	2.46	2.53	0.62	0.40
R12	BSR at Brandon	07/11/00	1400	00-6209	28.3	883	831	0.4	8.9	7.88	54	2200	111	739	628	2.34	0.05	2.24	2.29	0.82	0.51
R12	BSR at Brandon	08/16/00	1730	00-6301	23.7	1085	1112	0.6	11.5	8.32	15	230	32	500	468	6.96	0.05	2.06	2.11	1.39	1.22
R12	BSR at Brandon	09/20/00	1240	00-6358	15.7	1226	1489	0.8	9.9	8.24	9	230	40	1020	980	14.97	0.11	2.77	2.88	3.35	3.13
R12	BSR at Brandon	10/18/00	1230	00-6390	14.4	1022	1281	0.6	9.9	8.25	25	1200	28	810	782	9.48	0.15	2.37	2.52	2.28	1.92
R12	BSR at Brandon	04/04/01	1045	01-6036	2.0	194	------	0.2	12.6	8.30	195	160	382	598	216	1.55	0.92	2.64	3.56	0.92	0.33
R12	BSR at Brandon	04/12/01	1130	01-6065	8.3	345	506	0.2	4.3	7.70	9	1200	172	560	388	1.82	0.49	1.82	2.31	0.61	0.32
R12	BSR at Brandon	04/24/01	1140	01-6109	7.3	344	521	0.3	11.5	7.76	192	12000	198	638	440	1.40	0.29	1.81	2.10	0.70	0.27
R12	BSR at Brandon	05/08/01	1345	01-6164	14.9	710	887	0.4	9.6	7.90	29	2500	67	611	544	0.69	0.09	1.25	1.34	0.33	0.21
R12	BSR at Brandon	06/06/01	1130	01-6198	17.0	887	1045	0.5	12.3	8.39	30	300	92	846	754	1.00	0.02	1.29	1.32	0.37	0.19
R12	BSR at Brandon	06/13/01	1600	01-6213	21.3	683	735	0.4	8.1	8.20	394	26000	448	968	520	1.36	0.25	2.54	2.79	0.96	0.17
R12	BSR at Brandon	07/10/01	1200	01-6258	27.2	1116	1072	0.5	6.0	8.28	47	240	108	832	724	1.68	0.12	1.32	1.44	0.27	0.30
R12	BSR at Brandon	07/24/01	1230	01-6292	26.2	935	915	0.4	11.3	8.24	202	10000	513	1157	644	2.02	0.20	2.46	2.66	1.01	0.26
R12	BSR at Brandon	08/14/01	1230	01-6939	23.2	1048	1086	0.5	7.2	8.57	62	110	131	947	816	1.31	0.05	2.10	2.15	0.61	0.30
R12	BSR at Brandon	09/12/01	1015	01-6376	19.8	1040	1165	0.6	7.6	8.61	34	50	74	838	764	2.07	0.05	2.03	2.08	0.64	0.42
R12	BSR at Brandon	10/09/01	1000	01-6424	12.0	798	1062	0.5	15.4	8.36	30	110	59	839	780	3.11	0.10	2.26	2.36	0.57	0.27
R13	BSR nr Gitchie Manitou	06/12/00	1445	00-6136	24.0	971	989	0.5	9.1	8.44	55	250	113	849	736	1.48	0.10	2.03	2.13	0.54	0.19
R13	BSR nr Gitchie Manitou	07/11/00	1300	00-6208	26.5	780	759	0.4	6.2	7.17	69	4800	117	633	516	1.84	0.08	2.13	2.21	0.68	0.33
R13	BSR nr Gitchie Manitou	08/16/00	1630	00-6299	23.6	911	944	0.4	10.2	8.52	18	200	60	636	576	4.36	0.08	2.22	2.30	1.01	0.78
R13	BSR nr Gitchie Manitou	09/20/00	1200	00-6357	14.8	1018	1264	0.6	7.2	8.23	9	940	19	816	797	9.77	0.09	2.02	2.11	1.94	1.94
R13	BSR nr Gitchie Manitou	10/18/00	1300	00-6391	12.3	805	1064	0.5	8.4	8.08	26	290	26	754	728	5.51	0.10	2.50	2.60	1.31	1.13
R13	BSR nr Gitchie Manitou	04/04/01	1115	01-6037	2.7	183	318	0.1	7.5	8.62	162	80	292	552	260	1.84	0.86	2.36	3.22	0.88	0.33

R13	BSR nr Gitchie Manitou	04/12/01	1215	01-6067	8.1	341	504	0.2	2.8	7.78	114	2600	242	570	328	2.34	0.45	2.11	2.56	0.72	0.32
R13	BSR nr Gitchie Manitou	04/24/01	1240	01-6111	6.3	307	479	0.2	10.7	7.82	227	19000	206	522	316	1.76	0.36	1.93	2.29	0.72	0.25
R13	BSR nr Gitchie Manitou	05/08/01	1430	01-6165	14.4	679	850	0.4	8.0	7.88	27	3600	74	650	576	1.45	0.07	1.39	1.47	0.35	0.19
R13	BSR nr Gitchie Manitou	06/05/01	1340	01-6191	16.4	848	1013	0.5	11.6	8.30	22	300	69	785	716	1.58	0.09	1.31	1.41	0.33	0.19
R13	BSR nr Gitchie Manitou	06/13/01	1530	01-6212	19.4	342	383	0.2	6.2	8.00	2043	117000	1264	1569	305	2.57	0.70	6.56	7.27	2.89	0.22
R13	BSR nr Gitchie Manitou	07/10/01	1245	01-6259	26.6	1098	1065	0.5	5.2	8.22	50	320	108	788	680	2.28	0.15	1.33	1.47	0.34	0.29
R13	BSR nr Gitchie Manitou	07/24/01	1315	01-6293	24.7	640	644	0.3	11.1	8.23	413	20000	766	1138	372	1.76	0.23	2.85	3.08	1.34	0.21
R13	BSR nr Gitchie Manitou	08/14/01	1300	01-6940	22.5	992	1042	0.5	7.5	8.51	58	140	131	939	808	1.46	0.07	2.09	2.15	0.59	0.25
R13	BSR nr Gitchie Manitou	09/12/01	1045	01-6377	20.0	1027	1137	0.6	7.8	8.62	41	130	108	860	752	2.46	0.04	1.94	1.98	0.63	0.42
R13	BSR nr Gitchie Manitou	10/09/01	930	01-6423	12.2	733	969	0.5	13.7	8.45	29	280	59	783	724	3.18	0.05	2.04	2.09	0.62	0.33

Site	Stream	Date	Time	Lab#	Wtemp	Conduct	Spec Cond	Salinity	DO	pH	NTU	Fecal	Sups Sol	Tot Sol	Dis Sol	NO2 NO3	NH3N	Org Ntr	TKN	Tot PO4	TD PO4
T01	No Deer Ck (upper)	07/26/99	1348	99-6001	28.3	747	-------	0.4	7.4	8.07	29	500	48	616	568	0.02	0.14	1.52	1.65	0.22	0.12
T01	No Deer Ck (upper)	09/13/99	830	99-6043	13.1	886	-------	0.4	7.3	8.59	28	130	50	698	648	0.11	0.04	1.50	1.54	0.17	0.05
T01	No Deer Ck (upper)	10/12/99	1145	99-6083	11.6	923	-------	0.5	8.6	8.33	20	160	34	646	612	0.05	0.05	0.98	1.03	0.07	0.03
T01	No Deer Ck (upper)	03/12/00	1600	00-6003	1.2	498	-------	0.4	15.3	8.49	2	<1	3	631	628	0.60	0.02	0.63	0.65	0.04	0.04
T01	No Deer Ck (upper)	04/10/00	1400	00-6032	6.3	524	819	0.4	10.5	8.49	7	<10	6	580	574	0.06	0.04	0.42	0.46	0.03	0.01
T01	No Deer Ck (upper)	05/08/00	1015	00-6046	15.9	618	747	0.4	6.6	8.23	14	600	19	523	504	0.05	0.03	0.89	0.92	0.10	0.04
T01	No Deer Ck (upper)	05/16/00	1015	00-6071	13.4	614	788	0.4	7.0	8.23	9	600	11	563	552	0.04	0.09	0.62	0.72	0.06	0.03
T01	No Deer Ck (upper)	05/17/00	1800	00-6087	13.6	607	777	0.4	9.9	8.34	8	500	8	516	508	0.04	0.09	0.90	0.99	0.09	0.06
T01	No Deer Ck (upper)	06/13/00	1215	00-6160	21.0	741	-------	0.4	4.9	7.96	14	400	24	560	536	0.05	0.14	1.29	1.43	0.18	0.10
T01	No Deer Ck (upper)	06/28/00	1030	00-6176	18.3	589	674	0.3	5.2	7.95	7	30	8	404	396	0.14	0.11	1.35	1.46	0.27	0.24
T01	No Deer Ck (upper)	07/12/00	1000	00-6226	22.3	633	667	0.3	3.4	8.09	5	1900	10	410	400	0.14	0.21	1.02	1.22	0.30	0.26
T01	No Deer Ck (upper)	08/14/00	930	00-6258	25.2	757	755	0.4	6.5	7.84	19	800	46	574	528	0.05	0.10	1.53	1.62	0.08	0.24
T01	No Deer Ck (upper)	11/01/00	1020	00-6410	14.4	532	667	0.3	7.8	8.16	25	4500	35	887	852	0.12	0.14	0.83	0.97	0.13	0.06
T02	No Deer Ck (lower)	07/26/99	1146	99-6002	27.5	791	-------	0.4	16.5	8.48	8	200	9	557	548	0.02	0.06	0.92	0.98	0.12	0.09
T02	No Deer Ck (lower)	03/12/00	1630	00-6004	2.8	418	724	0.3	14.0	8.68	4	<1	6	394	388	0.55	0.02	0.79	0.81	0.04	0.03
T02	No Deer Ck (lower)	04/10/00	1215	00-6028	6.6	550	850	0.4	10.8	8.42	2	20	2	602	600	0.05	0.02	0.56	0.58	0.03	0.01
T02	No Deer Ck (lower)	05/08/00	1030	00-6047	15.3	613	753	0.4	6.5	8.18	6	3800	5	489	484	0.05	0.05	0.78	0.83	0.06	0.04
T02	No Deer Ck (lower)	05/16/00	1100	00-6072	13.5	707	907	0.4	8.0	8.14	5	300	8	584	576	0.03	0.15	0.81	0.96	0.05	0.03
T02	No Deer Ck (lower)	05/17/00	1720	00-6086	13.8	675	859	0.4	8.6	8.28	18	300	30	626	596	0.04	0.10	1.28	1.38	0.10	0.04
T02	No Deer Ck (lower)	06/13/00	1045	00-6156	21.0	816	-------	0.4	8.4	8.20	8	500	11	631	620	0.04	0.07	0.77	0.85	0.13	0.10
T02	No Deer Ck (lower)	06/28/00	940	00-6174	18.8	521	591	0.3	6.2	8.05	50	70	101	485	384	0.29	0.16	1.65	1.81	0.45	0.29
T02	No Deer Ck (lower)	07/12/00	1145	00-6230	23.8	383	393	0.2	4.2	8.13	59	39000	186	446	260	0.69	0.31	1.59	1.89	0.55	0.35
T02	No Deer Ck (lower)	11/02/00	950	00-6417	7.2	528	804	0.4	8.6	8.13	23	5900	54	578	524	1.71	0.18	1.36	1.54	0.34	0.24
T03	Six Mile Ck (upper)	07/26/99	1416	99-6003	27.7	758	-------	0.4	10.9	8.22	25	200	56	676	620	0.03	0.09	1.86	1.95	0.21	0.05
T03	Six Mile Ck (upper)	08/09/99	1230	99-6023	25.0	703	-------	0.3	6.6	8.53	32	250	47	635	588	0.07	0.07	2.26	2.33	0.23	0.05
T03	Six Mile Ck (upper)	09/13/99	900	99-6045	12.5	647	-------	0.3	7.3	8.72	20	30	39	439	400	0.13	0.05	1.49	1.54	0.13	0.02
T03	Six Mile Ck (upper)	10/12/99	1215	99-6085	12.7	652	-------	0.3	10.3	8.60	26	120	48	448	400	0.31	0.06	1.43	1.49	0.12	0.04
T03	Six Mile Ck (upper)	03/12/00	1530	00-6002	1.2	345	-------	0.3	14.9	8.62	5	<1	7	423	416	0.84	0.02	0.79	0.81	0.05	0.02
T03	Six Mile Ck (upper)	04/10/00	1430	00-6033	6.7	560	860	0.4	9.6	8.51	20	<10	28	624	596	0.30	0.02	0.97	0.98	0.09	0.01
T03	Six Mile Ck (upper)	05/08/00	945	00-6045	16.6	687	819	0.4	6.8	8.40	22	80	33	641	608	0.06	0.08	1.37	1.44	0.13	0.02
T03	Six Mile Ck (upper)	05/16/00	940	00-6070	13.6	634	809	0.4	8.4	8.29	9	<100	16	556	540	0.38	0.13	1.08	1.20	0.07	0.02
T03	Six Mile Ck (upper)	05/17/00	1815	00-6088	14.0	645	814	0.4	9.5	8.30	17	600	26	566	540	0.14	0.06	0.93	0.98	0.10	0.02
T03	Six Mile Ck (upper)	06/13/00	1330	00-6161	22.3	866	-------	0.4	7.0	8.12	12	800	26	702	676	0.32	0.16	1.26	1.41	0.11	0.01
T03	Six Mile Ck (upper)	06/28/00	1100	00-6177	19.3	550	613	0.3	5.0	7.83	27	<10	44	476	432	0.94	0.32	1.29	1.61	0.15	0.06
T03	Six Mile Ck (upper)	07/12/00	945	00-6215	22.9	567	566	0.3	4.0	6.90	29	1800	42	410	368	0.61	0.24	1.51	1.75	0.23	0.12
T03	Six Mile Ck (upper)	08/15/00	1030	00-6278	24.0	740	752	0.4	7.5	7.78	20	1800	39	547	508	0.15	0.16	1.79	1.95	0.22	0.04
T03	Six Mile Ck (upper)	09/05/00	1030	00-6312	17.3	519	693	0.3	6.1	8.39	19	200	38	502	464	0.05	0.13	1.65	1.78	0.19	0.03
T03	Six Mile Ck (upper)	10/16/00	1145	00-6364	9.0	497	719	0.3		8.36	19	10	19	479	460	0.37	0.49	1.76	2.24	0.14	0.03
T03	Six Mile Ck (upper)	11/01/00	1045	00-6412	14.4	491	674	0.3	5.5	8.29	23	600	31	415	384	0.46	0.45	1.69	2.14	0.20	0.04
T04	Six Mile Ck (middle)	07/26/99	1530	99-6004	29.5	851	-------	0.4	8.6	8.10	70	1200	102	670	568	0.55	0.29	1.86	2.15	0.26	0.07
T04	Six Mile Ck (middle)	08/09/99	1130	99-6024	23.7	873	-------	0.4	7.6	8.23	40	2700	57	657	600	0.21	0.17	1.10	1.28	0.16	0.04
T04	Six Mile Ck (middle)	08/30/99	845	99-6041	17.7	803	-------	0.4	5.9	8.10	29	5600	44	612	568	0.39	0.24	1.01	1.25	0.11	0.04
T04	Six Mile Ck (middle)	09/13/99	800	99-6046	11.5	842	-------	0.4	7.0	8.21	15	3100	25	577	552	0.64	0.13	0.74	0.86	0.07	0.04
T04	Six Mile Ck (middle)	10/12/99	1300	99-6086	12.0	790	-------	0.4	11.7	8.24	13	830	33	473	440	0.64	0.08	0.59	0.67	0.07	0.02
T04	Six Mile Ck (middle)	03/12/00	1430	00-6001	1.4	434	-------	0.4	16.0	8.47	7	<1	13	589	576	1.74	0.09	0.77	0.86	0.04	0.02
T04	Six Mile Ck (middle)	04/10/00	1345	00-6031	5.5	509	812	0.4	15.7	8.57	4	<10	4	560	556	1.20	0.02	0.82	0.84	0.03	0.01
T04	Six Mile Ck (middle)	05/08/00	915	00-6044	14.6	577	723	0.4	6.0	8.14	10	1100	15	527	512	0.46	0.15	1.01	1.15	0.08	0.03

T04	Six Mile Ck (middle)	05/11/00	1030	00-6068	15.2	655	807	0.4	7.5	8.16	9	200	16	544	528	0.39	0.07	0.85	0.92	0.06	0.02
T04	Six Mile Ck (middle)	05/16/00	900	00-6069	12.2	602	797	0.4	7.0	7.97	12	600	24	543	519	0.70	0.27	1.13	1.40	0.07	0.04
T04	Six Mile Ck (middle)	05/17/00	1830	00-6089	11.2	328	446	0.2	7.6	7.88	700	67000	436	776	340	0.93	0.51	3.87	4.38	1.41	0.25
T04	Six Mile Ck (middle)	06/13/00	1400	00-6163	21.2	779	841	0.4	7.7	7.95	40	2200	70	570	500	0.50	0.21	0.91	1.12	0.14	0.05
T04	Six Mile Ck (middle)	06/28/00	1150	00-6178	20.3	664	730	0.4	7.0	8.03	20	70	40	708	668	0.71	0.15	1.23	1.38	0.14	0.06
T04	Six Mile Ck (middle)	07/12/00	1015	00-6216	22.0	418	445	0.2	4.8	6.97	43	13000	62	366	304	0.82	0.14	1.67	1.81	0.42	0.25
T04	Six Mile Ck (middle)	08/05/00	1125	00-6257	24.0	764	779	0.4	6.5	7.54	32	-------	45	621	576	0.44	0.22	0.95	1.17	0.19	0.01
T04	Six Mile Ck (middle)	08/15/00	945	00-6275	23.5	784	807	0.4	5.1	7.76	52	1700	92	640	548	0.32	0.25	2.05	2.29	0.28	0.03
T04	Six Mile Ck (middle)	09/05/00	1100	00-6313	17.7	702	816	0.4	10.5	8.16	9	500	24	536	512	0.29	0.07	0.62	0.69	0.10	0.04
T04	Six Mile Ck (middle)	10/16/00	1115	00-6363	7.8	490	729	0.4	-------	8.22	12	200	8	596	588	1.04	0.12	0.60	0.72	0.03	0.02
T04	Six Mile Ck (middle)	11/01/00	1040	00-6411	14.6	606	755	0.4	8.3	8.03	19	2700	31	579	548	1.12	0.19	0.91	1.10	0.15	0.09
T05	Six Mile Ck (lower)	07/26/99	1309	99-6005	27.6	773	-------	0.4	9.2	8.19	17	500	25	521	496	0.25	0.22	0.90	1.12	0.15	0.11
T05	Six Mile Ck (lower)	08/09/99	1130	99-6025	22.6	860	-------	0.4	5.0	8.42	40	1800	44	616	572	0.14	0.22	1.19	1.40	0.20	0.11
T05	Six Mile Ck (lower)	08/30/99	930	99-6042	18.0	226	-------	0.1	5.6	8.30	130	11000	126	262	136	0.93	0.41	1.11	1.52	0.47	0.25
T05	Six Mile Ck (lower)	09/13/99	730	99-6047	12.4	485	-------	0.2	8.2	8.54	17	1900	29	481	452	0.08	0.08	1.05	1.13	0.11	0.03
T05	Six Mile Ck (lower)	10/12/99	1100	99-6087	13.3	850	-------	0.4	8.0	8.22	10	650	14	562	548	0.10	0.05	0.62	0.67	0.15	0.12
T05	Six Mile Ck (lower)	03/12/00	1700	00-6005	2.5	423	741	0.4	14.0	8.48	9	<1	15	531	516	1.17	0.04	0.79	0.83	0.06	0.02
T05	Six Mile Ck (lower)	04/10/00	1245	00-6029	6.1	490	767	0.4	14.0	8.71	5	300	6	526	520	0.41	0.02	0.61	0.62	0.05	0.01
T05	Six Mile Ck (lower)	05/08/00	1045	00-6048	15.7	414	504	0.2	4.8	8.01	26	1800	34	330	296	0.31	0.38	0.96	1.34	0.23	0.11
T05	Six Mile Ck (lower)	05/11/00	845	00-6067	14.8	261	323	0.2	5.0	7.95	140	30000	150	366	216	0.82	1.00	1.74	2.74	0.59	0.21
T05	Six Mile Ck (lower)	05/16/00	1115	00-6073	13.8	441	561	0.3	6.7	7.93	25	3700	48	416	368	0.28	0.23	1.07	1.30	0.27	0.14
T05	Six Mile Ck (lower)	05/17/00	1700	00-6085	12.1	262	347	0.2	8.0	8.65	260	20000	98	350	252	0.57	0.45	1.70	2.16	0.58	0.17
T05	Six Mile Ck (lower)	06/13/00	1140	00-6159	21.6	803	859	0.4	8.0	8.15	16	700	27	611	584	0.22	0.11	0.97	1.08	0.16	0.06
T05	Six Mile Ck (lower)	06/28/00	920	00-6190	18.9	647	733	0.4	5.7	8.01	80	230	157	761	604	0.36	0.16	1.65	1.81	0.36	0.06
T05	Six Mile Ck (lower)	07/12/00	1130	00-6229	26.0	674	661	0.3	4.7	8.44	36	2600	115	523	408	0.38	0.20	1.65	1.85	0.30	0.14
T05	Six Mile Ck (lower)	08/05/00	1040	00-6256	23.0	343	357	0.2	5.5	7.21	20	-------	29	239	210	0.73	0.27	0.90	1.17	0.19	0.13
T05	Six Mile Ck (lower)	08/14/00	1015	00-6260	25.2	726	728	0.4	5.8	7.80	16	1100	26	510	484	0.06	0.06	0.90	0.96	0.12	0.06
T05	Six Mile Ck (lower)	11/01/00	1000	00-6409	14.6	191	238	0.1	6.9	7.69	62	7900	54	212	158	0.64	0.38	0.85	1.22	0.41	0.27
T06	Deer Creek	07/26/99	1600	99-6006	29.5	966	-------	0.5	6.5	8.05	170	830	202	946	744	1.23	0.15	1.60	1.75	0.36	0.11
T06	Deer Creek	08/09/99	1430	99-6026	28.3	819	-------	0.4	7.9	8.57	22	1100	26	630	604	0.24	0.05	0.75	0.81	0.09	0.04
T06	Deer Creek	09/13/99	1030	99-6048	12.2	818	-------	0.4	8.3	8.52	13	900	16	524	508	0.08	0.02	0.59	0.60	0.05	0.02
T06	Deer Creek	10/12/99	1445	99-6088	13.9	768	-------	0.4	7.8	8.31	12	1400	15	511	496	0.05	0.05	0.48	0.53	0.05	0.02
T06	Deer Creek	03/13/00	1030	00-6009	1.7	560	-------	0.5	12.4	8.41	4	<1	4	708	704	0.38	0.02	0.44	0.46	0.03	0.03
T06	Deer Creek	04/10/00	915	00-6022	4.7	511	837	0.4	10.5	8.72	4	30	5	1113	1108	0.14	0.04	0.65	0.69	0.02	0.01
T06	Deer Creek	05/08/00	1215	00-6051	15.6	658	802	0.4	8.2	8.33	10	1600	15	567	552	0.03	0.02	0.89	0.92	0.06	0.01
T06	Deer Creek	05/16/00	1315	00-6076	16.7	758	901	0.4	10.1	8.42	10	600	14	660	646	0.03	0.20	0.63	0.82	0.06	0.00
T06	Deer Creek	05/17/00	1920	00-6090	12.3	607	802	0.4	9.4	8.21	340	800	394	986	592	0.20	0.10	2.27	2.37	0.70	0.04
T06	Deer Creek	05/31/00	1215	00-6109	17.0	793	935	0.5	8.0	8.09	29	700	88	800	712	0.36	0.17	1.20	1.38	0.21	0.06
T06	Deer Creek	06/13/00	1345	00-6162	20.9	828	898	0.4	8.7	8.17	10	1300	23	643	620	0.06	0.05	0.61	0.66	0.04	0.02
T06	Deer Creek	06/28/00	1230	00-6179	20.6	810	-------	0.4	7.5	8.25	37	60	80	760	680	0.37	0.19	0.85	1.03	0.15	0.06
T06	Deer Creek	07/12/00	1045	00-6217	24.0	657	670	0.3	5.7	7.13	67	1200	135	667	532	0.52	0.18	1.77	1.95	0.40	0.14
T06	Deer Creek	08/15/00	1120	00-6279	24.0	760	773	0.4	7.0	7.94	25	3300	38	610	572	0.33	0.07	0.92	0.99	0.15	0.05
T07	Medary Ck (upper)	07/27/99	930	99-6007	21.6	699	-------	0.3	7.2	7.99	18	820	28	560	532	3.40	0.13	1.30	1.43	0.15	0.09
T07	Medary Ck (upper)	08/09/99	1315	99-6027	26.4	489	-------	0.2	8.2	8.72	17	900	30	378	348	2.67	0.03	1.24	1.27	0.12	0.03
T07	Medary Ck (upper)	09/13/99	930	99-6049	12.5	661	-------	0.3	8.2	8.42	17	1500	24	412	388	5.04	0.05	0.94	0.99	0.10	0.04
T07	Medary Ck (upper)	10/12/99	1545	99-6089	13.3	518	-------	0.3	11.7	8.50	5	480	8	348	340	5.01	0.08	0.58	0.66	0.03	0.04
T07	Medary Ck (upper)	03/13/00	1230	00-6014	3.4	382	651	0.3	13.8	8.36	2	<1	2	426	424	3.71	0.03	0.71	0.74	0.03	0.01
T07	Medary Ck (upper)	04/10/00	1545	00-6035	6.8	334	502	0.2	12.5	8.52	5	10	2	398	396	3.66	0.02	0.61	0.63	0.03	0.02
T07	Medary Ck (upper)	05/08/00	1315	00-6053	15.0	435	537	0.3	9.0	8.31	8	1400	6	386	380	2.07	0.08	0.90	0.98	0.07	0.05

T07	Medary Ck (upper)	05/16/00	1415	00-6078	16.8	514	608	0.3	14.3	8.71	5	100	7	423	416	1.93	0.06	0.89	0.95	0.04	0.01
T07	Medary Ck (upper)	05/17/00	2015	00-6092	13.4	471	604	0.3	8.0	8.19	33	1700	48	512	464	1.43	0.15	1.28	1.43	0.12	0.03
T07	Medary Ck (upper)	05/31/00	1300	00-6111	16.6	371	441	0.2	6.2	7.78	95	3700	102	394	292	1.51	0.18	1.64	1.82	0.39	0.16
T07	Medary Ck (upper)	06/13/00	1520	00-6167	20.5	591	638	0.3	8.4	8.20	6	400	7	419	412	2.14	0.08	0.80	0.88	0.06	0.01
T07	Medary Ck (upper)	06/28/00	1330	00-6181	21.9	486	517	0.3	9.7	8.41	9	60	12	268	256	1.71	0.11	1.01	1.12	0.13	0.07
T07	Medary Ck (upper)	07/12/00	1200	00-6219	25.2	325	323	0.2	8.4	7.47	19	4600	58	442	384	1.49	0.19	1.82	2.01	0.24	0.09
T07	Medary Ck (upper)	08/15/00	1300	00-6281	24.6	557	564	0.3	8.8	7.94	9	530	16	388	372	2.27	0.11	1.20	1.31	0.11	0.05
T07	Medary Ck (upper)	09/05/00	1215	00-6315	18.7	470	535	0.3	9.5	8.06	4	1400	8	330	322	3.57	0.16	0.98	1.13	0.07	0.05
T07	Medary Ck (upper)	10/16/00	1215	00-6365	9.0	407	586	0.3		8.25	12	6000	5	421	416	6.33	0.11	1.38	1.49	0.06	0.03
T07	Medary Ck (upper)	11/01/00	1215	00-6415	15.0	464	559	0.3	8.7	8.17	18	4500	21	365	344	3.77	0.17	1.50	1.67	0.12	0.06
T08	Medary Ck (middle)	07/27/99	900	99-6008	22.2	774	-------	0.4	7.1	7.98	22	730	29	553	524	1.34	0.13	1.10	1.24	0.18	0.09
T08	Medary Ck (middle)	08/09/99	1400	99-6028	28.4	707	-------	0.3	8.8	8.54	32	1500	40	500	460	0.34	0.06	1.75	1.81	0.15	0.05
T08	Medary Ck (middle)	08/24/99	1345	99-6039	25.3	693	-------	0.3	13.1	8.58	23	840	37	555	518	0.25	0.07	1.79	1.87	0.04	0.18
T08	Medary Ck (middle)	09/13/99	1000	99-6050	12.5	716	-------	0.4	9.0	8.40	19	100	21	429	408	1.52	0.06	0.78	0.85	0.08	0.03
T08	Medary Ck (middle)	10/12/99	1515	99-6090	14.4	560	-------	0.3	11.2	8.50	11	50	10	354	344	1.02	0.06	0.52	0.58	0.18	0.02
T08	Medary Ck (middle)	03/13/00	1200	00-6013	2.6	406	711	0.3	13.8	8.43	4	<1	21	365	344	3.77	0.17	1.50	1.67	0.12	0.06
T08	Medary Ck (middle)	04/10/00	1515	00-6034	7.7	397	593	0.3	14.0	8.65	4	<10	4	460	456	1.39	0.03	0.58	0.62	0.02	0.01
T08	Medary Ck (middle)	05/08/00	1245	00-6052	15.6	495	603	0.3	8.4	8.24	14	1300	17	293	276	0.13	0.08	0.83	0.91	0.08	0.01
T08	Medary Ck (middle)	05/16/00	1330	00-6077	16.6	105	124	0.1	11.4	8.50	19	300	36	480	444	0.30	0.14	0.86	1.01	0.09	0.01
T08	Medary Ck (middle)	05/17/00	1945	00-6091	13.5	565	725	0.4	9.4	8.27	25	2600	69	561	492	0.66	0.13	1.19	1.32	0.17	0.02
T08	Medary Ck (middle)	05/31/00	1230	00-6110	16.9	390	461	0.2	5.6	7.78	55	9000	86	434	348	0.92	0.20	1.60	1.80	0.54	0.32
T08	Medary Ck (middle)	06/13/00	1500	00-6166	21.1	644	-------	0.3	9.2	8.24	9	800	10	458	448	0.69	0.08	0.64	0.72	0.07	0.01
T08	Medary Ck (middle)	06/28/00	1310	00-6180	21.6	642	1607	0.3	10.7	8.37	12	80	28	708	680	1.10	0.10	0.98	1.07	0.10	0.06
T08	Medary Ck (middle)	07/12/00	1130	00-6218	25.3	582	586	0.3	8.3	7.33	2	400	14	506	492	0.36	0.25	1.19	1.44	0.26	0.16
T08	Medary Ck (middle)	08/15/00	1220	00-6280	24.0	630	642	0.3	10.2	8.06	15	600	26	434	408	0.16	0.03	1.60	1.63	0.22	0.06
T08	Medary Ck (middle)	09/05/00	1145	00-6314	19.4	573	640	0.3	12.0	8.27	1	<100	10	422	412	0.99	0.12	1.18	1.30	0.04	0.03
T08	Medary Ck (middle)	10/16/00	1215	00-6366	8.2	448	661	0.3		8.25	12	<10	7	415	408	1.19	0.11	0.36	0.47	0.03	0.02
T08	Medary Ck (middle)	11/01/00	1145	00-6414	16.6	634	754	0.4	5.4	8.12	10	300	11	551	540	0.14	0.03	0.83	0.86	0.11	0.05
T09	Medary Ck (lower)	07/27/99	1000	99-6009	23.0	753	-------	0.4	7.9	8.02	100	1100	117	713	596	0.93	0.06	1.67	1.73	0.26	0.03
T09	Medary Ck (lower)	08/09/99	1515	99-6029	29.9	764	-------	0.4	12.3	8.50	26	420	47	631	584	0.73	0.05	0.85	0.91	0.11	0.03
T09	Medary Ck (lower)	09/13/99	1130	99-6051	12.9	752	-------	0.4	8.9	8.44	17	530	20	464	444	1.36	0.06	0.71	0.77	0.06	0.02
T09	Medary Ck (lower)	10/12/99	1345	99-6091	13.6	706	-------	0.3	12.0	8.28	8	110	11	501	490	0.62	0.04	0.49	0.53	0.03	0.03
T09	Medary Ck (lower)	03/13/00	950	00-6008	0.3	405	-------	0.4	13.7	8.64	5	<1	12	472	460	1.71	0.07	0.52	0.59	0.04	0.02
T09	Medary Ck (lower)	03/29/00	1215	00-6021	9.3	293	420	0.2	15.0	8.36	1	-------	5	495	490	1.28	0.01	0.84	0.85	0.03	0.01
T09	Medary Ck (lower)	04/10/00	1045	00-6025	5.5	352	561	0.3	11.0	8.45	5	20	6	574	568	1.18	0.05	0.61	0.67	0.03	0.01
T09	Medary Ck (lower)	05/08/00	1200	00-6050	15.5	562	689	0.3	7.2	8.18	28	7200	59	495	436	0.61	0.15	1.03	1.18	0.13	0.02
T09	Medary Ck (lower)	05/16/00	1245	00-6075	15.3	518	638	0.3	9.0	8.17	30	300	65	549	484	0.73	0.12	1.03	1.15	0.13	0.00
T09	Medary Ck (lower)	05/17/00	2045	00-6093	13.5	604	774	0.4	7.9	8.25	31	100	63	556	493	0.56	0.18	0.91	2.52	0.14	0.02
T09	Medary Ck (lower)	05/31/00	1145	00-6108	17.1	586	690	0.3	7.4	8.27	65	2800	140	660	520	0.69	0.22	1.31	1.53	0.35	0.13
T09	Medary Ck (lower)	06/13/00	1050	00-6157	20.7	743	810	0.4	6.7	8.06	38	300	83	631	548	1.32	0.12	0.94	1.06	0.20	0.03
T09	Medary Ck (lower)	06/28/00	1430	00-6183	22.8	671	702	0.3	9.2	8.31	30	90	54	662	608	0.74	0.12	1.05	1.17	0.16	0.05
T09	Medary Ck (lower)	07/12/00	1340	00-6232	27.3	591	566	0.3	5.4	7.85	43	600	123	579	456	0.56	0.17	1.68	1.86	0.29	0.11
T09	Medary Ck (lower)	08/14/00	1115	00-6262	26.0	787	776	0.4	10.5	8.04	18	470	32	524	492	0.56	0.04	1.14	1.18	0.13	0.02
T09	Medary Ck (lower)	09/05/00	1300	00-6316	20.1	673	741	0.4	11.6	8.20	11	300	31	1011	980	0.58	0.11	0.64	0.75	0.11	0.04
T09	Medary Ck (lower)	10/16/00	1040	00-6362	7.9	507	772	0.4		8.09	10	270	8	568	560	2.09	0.11	0.66	0.76	0.03	0.01
T09	Medary Ck (lower)	11/01/00	930	00-6407	14.6	518	647	0.3	8.0	8.20	29	1500	66	474	408	1.09	0.14	0.90	1.04	0.14	0.04
T10	Lake Campbell Outlet	03/12/00	1745	00-6007	3.0	847	1427	0.7	20.0	8.07	12	<1	7	1063	1056	0.10	1.88	0.69	2.58	0.20	0.06
T10	Lake Campbell Outlet	04/10/00	1115	00-6026	6.7	964	1482	0.7	12.4	8.03	16	10	22	1230	1208	0.10	0.95	1.20	2.15	0.33	0.06
T10	Lake Campbell Outlet	05/08/00	1115	00-6049	14.9	1723	1393	0.9	7.1	7.82	32	1600	64	1380	1316	0.06	1.67	1.57	3.24	0.44	0.16

T10	Lake Campbell Outlet	05/16/00	1200	00-6074	17.3	1655	1940	1.0	2.9	7.63	190	500	206	1810	1604	0.05	1.57	1.85	3.41	0.60	0.14
T10	Lake Campbell Outlet	05/22/00	930	00-6107	18.5	1721	1965	1.0	8.2	8.14	10	<10	28	1696	1668	0.15	0.30	1.18	1.48	0.10	0.04
T10	Lake Campbell Outlet	06/13/00	1000	00-6155	22.7	1507	1577	0.6	7.1	8.19	19	110	29	1513	1484	0.05	0.07	1.41	1.48	0.13	0.03
T10	Lake Campbell Outlet	08/14/00	1035	00-6261	27.0	1790	1726	0.9	6.2	7.75	53	7200	62	1358	1296	0.07	5.95	9.77	15.72	1.39	0.03
T10	Lake Campbell Outlet	09/05/00	930	00-6311	14.7	1142	1570	0.0	6.7	8.00	5	100	10	1178	1168	0.10	3.45	1.51	4.96	0.27	0.19
T10	Lake Campbell Outlet	10/16/00	1015	00-6361	8.4	874	1280	0.6	-------	7.89	40	<10	64	1264	1200	18.48	3.26	10.72	13.98	0.42	0.08
T11	Spring Creek	07/27/99	1100	99-6010	24.1	745	-------	0.4	7.0	8.00	25	860	36	652	616	2.39	0.12	1.04	1.16	0.29	0.23
T11	Spring Creek	08/10/99	1100	99-6030	24.1	720	-------	0.4	8.1	8.27	15	1300	19	599	580	2.79	0.11	0.71	0.82	0.15	0.12
T11	Spring Creek	09/13/99	1230	99-6052	13.9	550	-------	0.3	8.7	8.50	9	270	12	560	548	3.77	0.03	0.96	0.99	0.09	0.07
T11	Spring Creek	10/12/99	1700	99-6092	13.3	598	-------	0.3	14.0	8.74	3	170	3	451	448	2.65	0.00	0.68	0.68	0.01	0.03
T11	Spring Creek	03/12/00	1330	00-6015	3.4	427	727	0.4	13.1	8.47	5	<1	4	468	464	4.19	0.04	0.50	0.54	0.06	0.05
T11	Spring Creek	04/11/00	950	00-6036	4.6	243	398	0.2	12.6	8.70	2	40	3	419	416	2.74	0.01	0.91	0.92	0.02	0.01
T11	Spring Creek	05/08/00	1345	00-6054	16.3	491	589	0.3	8.2	8.18	7	1900	7	317	310	1.09	0.14	0.81	0.95	0.07	0.05
T11	Spring Creek	05/16/00	1435	00-6079	17.9	561	-------	0.3	10.6	8.49	16	2200	26	522	496	1.62	0.09	1.11	1.19	0.12	0.09
T11	Spring Creek	05/19/00	1045	00-6098	12.6	364	478	0.2	7.2	7.86	80	7600	102	430	328	1.09	0.23	1.97	2.21	0.68	0.43
T11	Spring Creek	05/31/00	1345	00-6112	18.1	347	399	0.2	7.5	7.90	110	9000	102	366	264	1.16	0.24	1.66	1.90	0.61	0.34
T11	Spring Creek	06/14/00	945	00-6150	17.8	608	702	0.3	6.4	8.21	14	2400	21	525	504	1.48	0.16	0.76	0.91	0.18	0.15
T11	Spring Creek	07/12/00	1230	00-6220	25.8	435	429	0.2	5.1	7.49	49	5300	76	544	468	1.74	0.23	1.28	1.51	0.35	0.20
T11	Spring Creek	08/15/00	1345	00-6282	24.7	719	722	0.4	6.7	7.90	20	580	30	506	476	1.93	0.15	1.05	1.20	0.22	0.17
T11	Spring Creek	09/05/00	1345	00-6317	20.6	627	685	0.3	9.1	8.15	15	1600	26	530	504	2.94	0.07	0.83	0.90	0.18	0.11
T11	Spring Creek	10/16/00	1315	00-6367	9.1	414	596	0.3	2.6	8.53	10	60	-------	-------	-------	-------	-------	-------	-------	-------	-------
T12	Flandreau Creek	07/27/99	1200	99-6011	26.0	831	-------	0.4	6.2	8.05	39	1500	47	683	636	1.56	0.17	1.14	1.31	0.33	0.25
T12	Flandreau Creek	08/10/99	1145	99-6031	23.6	762	-------	0.4	9.2	8.39	14	900	17	553	536	0.47	0.11	0.73	0.84	0.15	0.09
T12	Flandreau Creek	09/13/99	1300	99-6053	13.2	355	-------	0.2	8.1	8.50	20	1300	29	629	600	1.06	0.11	0.74	0.85	0.16	0.10
T12	Flandreau Creek	10/12/99	1745	99-6093	13.7	716	-------	0.4	13.2	8.71	10	110	14	498	484	0.17	0.06	0.53	0.59	0.05	0.03
T12	Flandreau Creek	03/13/00	1400	00-6016	3.9	468	785	0.4	14.2	8.52	6	15	8	540	532	1.37	0.06	0.60	0.66	0.06	0.04
T12	Flandreau Creek	04/11/00	1030	00-6038	4.8	487	792	0.4	12.3	8.54	4	110	5	525	520	0.18	0.01	0.54	0.54	0.03	0.02
T12	Flandreau Creek	05/08/00	1415	00-6055	16.6	584	696	0.3	7.8	8.28	25	1300	38	450	412	0.17	0.16	0.90	1.06	0.13	0.03
T12	Flandreau Creek	05/16/00	1510	00-6080	17.5	544	631	0.3	8.2	8.28	50	7500	73	517	444	0.59	0.18	1.25	1.42	0.20	0.08
T12	Flandreau Creek	05/19/00	1120	00-6100	13.2	361	468	0.2	7.1	7.82	170	6900	267	571	304	1.30	0.20	2.42	2.62	0.60	0.20
T12	Flandreau Creek	05/31/00	1400	00-6113	16.5	276	330	0.2	6.3	7.76	450	10000	308	544	236	1.07	0.17	2.38	2.55	0.80	0.22
T12	Flandreau Creek	06/14/00	1030	00-6151	17.3	648	760	0.4	7.1	8.31	15	670	21	521	500	1.03	0.18	0.77	0.95	0.13	0.09
T12	Flandreau Creek	07/12/00	1315	00-6221	28.0	497	468	0.2	5.1	7.18	34	3100	41	469	428	0.37	0.32	1.62	1.95	0.34	0.15
T12	Flandreau Creek	08/15/00	1400	00-6283	24.7	790	794	0.4	8.2	7.93	14	270	22	498	476	0.57	0.19	1.09	1.27	0.27	0.19
T12	Flandreau Creek	09/05/00	1400	00-6318	20.0	627	694	0.3	9.6	8.18	11	600	24	552	528	0.58	0.18	0.77	0.95	0.18	0.13
T12	Flandreau Creek	10/16/00	1340	00-6368	9.2	562	806	0.4	2.6	8.54	11	700	6	554	548	0.20	0.03	0.45	0.48	0.08	0.07
T13	Jack Moore Creek	07/27/99	1415	99-6012	28.7	1308	-------	0.7	8.0	7.95	34	1800	63	1209	1146	1.09	0.21	2.19	2.39	0.55	0.41
T13	Jack Moore Creek	08/10/99	1330	99-6032	28.2	1029	-------	0.5	11.6	8.48	19	3200	34	1430	1396	0.03	0.18	1.90	2.08	0.28	0.12
T13	Jack Moore Creek	09/13/99	1445	99-6054	14.7	1071	-------	0.5	7.2	8.47	13	-------	17	777	760	0.20	0.11	1.81	1.92	0.20	0.08
T13	Jack Moore Creek	10/12/99	1845	99-6094	12.3	1018	-------	0.5	6.3	7.88	11	670	17	741	724	0.14	0.03	1.48	1.51	0.12	0.06
T13	Jack Moore Creek	03/14/00	645	00-6018	1.7	719	-------	0.6	11.8	8.35	3	2	4	916	912	0.17	0.05	1.38	1.42	0.10	0.07
T13	Jack Moore Creek	04/11/00	1130	00-6040	6.5	802	1242	0.6	10.4	8.23	3	360	2	894	892	0.11	0.03	1.34	1.37	0.15	0.11
T13	Jack Moore Creek	05/08/00	1445	00-6056	16.7	1049	1248	0.6	6.5	8.18	12	5800	23	955	932	0.05	0.06	1.23	1.29	0.18	0.09
T13	Jack Moore Creek	05/16/00	1545	00-6081	18.6	1119	-------	0.6	13.8	8.60	8	700	13	1069	1056	0.04	0.10	1.04	1.13	0.11	0.09
T13	Jack Moore Creek	05/19/00	1230	00-6102	13.2	633	1818	0.4	7.0	7.82	35	13500	59	639	580	1.16	0.12	1.72	1.84	0.55	0.40
T13	Jack Moore Creek	05/31/00	1445	00-6114	20.3	1136	1252	0.4	6.4	8.08	35	19000	67	947	880	0.46	0.24	1.49	1.73	0.35	0.21
T13	Jack Moore Creek	06/14/00	1140	00-6153	17.7	1077	1251	0.6	5.3	8.10	9	1100	12	920	908	0.58	0.32	1.38	1.69	0.28	0.24
T13	Jack Moore Creek	07/12/00	1400	00-6222	28.5	1006	938	0.5	7.8	7.55	12	5800	23	711	688	0.32	0.20	1.97	2.17	0.44	0.26
T13	Jack Moore Creek	09/05/00	1445	00-6321	22.1	861	913	0.5	6.1	8.14	0	1400	13	653	640	0.16	0.15	1.07	1.22	0.23	0.20

T13	Jack Moore Creek	10/16/00	1400	00-6369	9.3	565	801	0.4		7.75	11	800	9	732	723	0.05	0.07	1.15	1.22	0.18	0.08
T14	Bachelor Creek	05/08/00	1530	00-6057	15.9	920	1111	0.6	7.4	8.02	18	55000	34	906	872	1.72	0.27	1.80	2.07	0.42	0.32
T14	Bachelor Creek	05/16/00	1545	00-6082	19.6	1486	1657	0.8	13.2	8.38	3	1100	9	1413	1404	0.58	0.09	1.06	1.15	0.11	0.08
T14	Bachelor Creek	05/19/00	1245	00-6103	14.5	957	1182	0.6	8.2	7.89	110	30000	266	1198	932	2.28	0.31	2.73	3.03	0.80	0.31
T14	Bachelor Creek	06/13/00	1100	00-6141	20.7	229	250	0.1	8.3	8.10	3	1000	13	1281	1268	0.36	0.06	1.31	1.37	0.07	0.03
T14	Bachelor Creek	06/14/00	1215	00-6154	16.8	1369	1625	0.8	10.7	-------	4	1200	11	1343	1332	0.81	0.08	0.82	0.89	0.08	0.05
T14	Bachelor Creek	07/12/00	1430	00-6223	27.0	715	782	0.3	7.1	7.42	33	10000	48	456	408	1.47	0.21	1.38	1.59	0.43	0.21
T14	Bachelor Creek	08/15/00	1530	00-6285	24.6	1170	1176	0.6	10.5	7.88	2	580	9	937	928	0.76	0.43	1.45	1.89	0.08	0.05
T14	Bachelor Creek	09/05/00	1530	00-6324	23.1	1131	1173	0.6	13.0	8.20	0	800	5	889	884	0.72	0.11	0.67	0.78	0.07	0.05
T14	Bachelor Creek	10/16/00	1410	00-6370	10.2	825	1149	0.6	4.3	8.18	7	1800	6	906	900	1.20	0.14	0.46	0.60	0.09	0.04
T15	North Buffalo Creek	06/12/00	1010	00-6127	20.5	1768	1932	1.0	6.0	7.99	55	3100	110	1862	1752	0.51	0.22	1.43	1.65	0.32	0.14
T15	North Buffalo Creek	07/12/00	1530	00-6233	31.7	1638	1452	0.7	6.6	7.73	28	2800	97	1425	1328	0.37	0.12	1.95	2.07	0.45	0.13
T15	North Buffalo Creek	08/14/00	1300	00-6265	31.0	682	586	0.6	9.5	8.16	14	3400	46	1170	1124	0.12	0.04	1.60	1.64	0.29	0.09
T15	North Buffalo Creek	08/17/00	1300	00-6310	23.0	1276	1333	0.7	5.8	7.76	129	5800	227	1283	1056	0.35	0.25	2.22	2.47	0.60	0.11
T15	North Buffalo Creek	09/18/00	1015	00-6333	18.1	1040	1224	0.0	5.2	7.87	105	460	324	1252	928	0.15	0.14	1.94	2.07	0.53	0.11
T15	North Buffalo Creek	10/19/00	1100	00-6397	12.6	1023	1344	0.7	5.3	7.98	89	2800	100	1096	996	0.14	0.14	1.13	1.27	0.31	0.04
T15	North Buffalo Creek	04/03/01	1030	01-6024	1.5	293	-------	0.3	9.8	8.50	12	100	18	398	380	1.30	0.56	1.32	1.88	0.59	0.58
T15	North Buffalo Creek	04/12/01	1115	01-6076	5.0	636	1026	0.5	-------	7.81	6	600	12	774	762	1.43	0.32	1.07	1.40	0.38	0.35
T15	North Buffalo Creek	04/23/01	1000	01-6116	2.0	401	721	0.3	10.5	7.75	39	6800	41	357	316	1.73	0.13	1.64	1.77	0.42	0.31
T15	North Buffalo Creek	05/07/01	930	01-6127	10.6	980	1352	0.7	10.2	7.58	5	4700	8	1076	1068	0.32	0.05	0.98	1.03	0.22	0.18
T15	North Buffalo Creek	06/04/01	1100	01-6172	17.2	1233	1448	0.7	12.7	8.39	20	<100	45	1229	1184	0.05	0.12	1.90	2.03	0.27	0.06
T15	North Buffalo Creek	06/13/01	930	01-6901	17.5	1216	1416	0.7	8.1	7.96	45	16000	94	1290	1196	1.17	0.21	1.68	1.88	0.43	0.24
T15	North Buffalo Creek	07/09/01	1030	01-6234	24.5	1561	1576	0.8	9.8	7.94	12	1800	33	1229	1196	0.23	0.07	0.98	1.06	0.18	0.08
T15	North Buffalo Creek	08/13/01	1100	01-6927	20.0	1168	1296	0.6	8.6	7.85	18	<100	26	1034	1008	0.31	0.34	1.20	1.53	0.14	0.08
T15	North Buffalo Creek	09/10/01	1000	01-6353	15.0	1100	1370	0.7	13.5	8.04	8	540	11	903	892	0.15	0.05	0.73	0.78	0.09	0.05
T15	North Buffalo Creek	10/09/01	1100	01-6410	10.3	758	1057	0.5	4.5	8.27	8	360	13	993	980	0.28	0.05	0.47	0.51	0.07	0.05
T16	Buffalo Creek	06/12/00	1030	00-6128	22.9	1374	1430	0.7	3.8	8.21	55	50	87	1415	1328	0.03	0.18	2.59	2.77	0.37	0.04
T16	Buffalo Creek	07/12/00	1545	00-6234	31.4	1678	1495	0.7	10.7	8.49	61	200	94	1382	1288	0.06	0.12	5.02	5.14	0.63	0.04
T16	Buffalo Creek	08/14/00	1340	00-6266	30.0	1827	1618	0.8	6.8	8.06	29	640	55	1383	1328	0.06	0.28	3.96	4.25	0.45	0.15
T16	Buffalo Creek	09/18/00	1030	00-6334	18.6	1557	1770	0.9	3.8	7.80	14	140	25	1509	1484	0.05	0.31	3.17	3.48	0.35	0.11
T16	Buffalo Creek	10/19/00	1115	00-6398	12.4	1400	1840	0.9	4.3	7.92	28	30	25	1505	1480	0.08	2.14	2.44	4.59	0.27	0.09
T16	Buffalo Creek	04/03/01	1045	01-6025	1.0	232	-------	0.2	9.0	8.24	12	130	12	344	332	1.01	0.77	1.27	2.04	0.68	0.58
T16	Buffalo Creek	04/12/01	1200	01-6077	4.5	395	890	0.3	-------	7.94	57	640	147	772	625	1.03	0.62	2.70	3.32	0.68	0.29
T16	Buffalo Creek	04/23/01	1045	01-6117	4.7	646	1054	0.5	9.8	8.03	98	200	132	720	588	0.43	0.34	2.61	2.95	0.47	0.09
T16	Buffalo Creek	05/07/01	1000	01-6128	12.1	890	1182	0.6	8.8	10.89	66	2200	136	1004	868	0.18	0.23	1.91	2.14	0.38	0.11
T16	Buffalo Creek	06/04/01	1030	01-6171	15.2	1333	1640	0.8	10.7	7.96	26	500	62	1402	1340	0.49	0.13	1.09	1.22	0.21	0.09
T16	Buffalo Creek	06/13/01	1000	01-6902	18.8	1207	1370	0.7	9.2	8.36	92	1000	172	1332	1160	0.12	0.21	2.55	2.76	0.40	0.09
T16	Buffalo Creek	07/09/01	1100	01-6235	27.8	1596	1515	0.8	5.0	8.31	13	120	25	1201	1176	0.04	0.13	1.56	1.69	0.19	0.09
T17	Brant Lake Outlet	06/12/00	945	00-6126	20.9	1508	1636	0.8	5.3	8.19	9	120	21	1365	1344	0.34	0.87	1.55	2.42	0.17	0.08
T17	Brant Lake Outlet	07/12/00	1445	00-6231	34.8	1834	1548	0.8	8.2	8.11	9	200	23	1191	1168	0.26	0.24	2.08	2.31	0.16	0.08
T17	Brant Lake Outlet	08/14/00	1230	00-6264	31.1	1687	1478	0.7	9.5	8.72	10	4000	35	1107	1072	0.12	0.05	2.62	2.66	0.28	0.06
T17	Brant Lake Outlet	09/18/00	1000	00-6332	17.5	1219	1428	0.7	8.2	8.02	7	9800	7	1167	1160	0.07	0.04	0.70	0.74	0.04	0.03
T17	Brant Lake Outlet	10/19/00	1030	00-6396	12.3	793	1051	0.5	10.3	8.00	6	380	6	942	936	0.82	0.11	0.67	0.78	0.04	0.04
T17	Brant Lake Outlet	04/03/01	1000	01-6023	0.1	895	-------	0.8	10.4	9.00	6	10	6	1350	1344	0.50	0.86	1.26	2.12	0.25	0.19
T17	Brant Lake Outlet	04/12/01	945	01-6073	4.1	1066	1772	0.9	-------	7.75	6	20	10	1350	1340	0.34	0.71	1.34	2.05	0.24	0.16
T17	Brant Lake Outlet	04/23/01	930	01-6115	5.0	933	1512	0.8	10.5	8.35	21	16000	32	1217	1185	0.30	0.12	1.56	0.17	0.19	0.04
T17	Brant Lake Outlet	05/07/01	900	01-6126	12.8	1185	1542	0.8	8.7	8.64	6	<100	9	1117	1108	0.08	0.24	1.10	1.34	0.09	0.04
T17	Brant Lake Outlet	06/04/01	1000	01-6170	15.8	1293	1572	0.8	11.3	8.09	14	<100	34	1294	1260	0.23	0.46	1.64	2.11	0.20	0.07
T17	Brant Lake Outlet	06/13/01	900	01-6900	18.6	1301	1477	0.7	-------	-------	-------	2000	67	1285	1218	0.24	0.50	1.76	2.26	0.30	0.11

T17	Brant Lake Outlet	07/09/01	1000	01-6233	25.2	1600	1595	0.8	5.4	8.22	13	80	17	1205	1188	0.07	0.32	1.55	1.87	0.13	0.07
T17	Brant Lake Outlet	08/13/01	1000	01-6926	21.5	1390	1474	0.7	9.7	7.83	9	<100	11	1231	1220	0.40	0.76	1.61	2.37	0.35	0.27
T17	Brant Lake Outlet	09/10/01	915	01-6352	14.1	1162	1470	0.8	14.3	8.55	2	330	3	1091	1088	0.36	0.09	0.83	0.92	0.15	0.14
T17	Brant Lake Outlet	10/09/01	1030	01-6409	11.8	1035	1422	0.7	4.2	7.90	3	1400	5	1137	1132	5.84	0.12	0.84	0.97	0.07	0.05
T18	Skunk Ck (upper)	06/12/00	1110	00-6129	21.7	1472	1573	0.8	10.0	8.37	55	1100	127	1411	1284	0.06	0.20	3.02	3.21	0.44	0.08
T18	Skunk Ck (upper)	07/13/00	1100	00-6224	29.0	1473	1369	0.7	9.5	7.71	66	1600	151	1330	1179	0.07	0.08	3.45	3.52	0.38	0.05
T18	Skunk Ck (upper)	08/14/00	1400	00-6267	30.2	1100	999	0.8	10.0	7.89	50	8300	152	864	712	0.15	0.07	2.72	2.79	0.40	0.06
T18	Skunk Ck (upper)	09/18/00	1100	00-6335	16.4	775	926	0.5	6.8	7.74	33	9100	62	750	688	0.26	0.15	1.08	1.24	0.21	0.04
T18	Skunk Ck (upper)	10/19/00	1145	00-6399	12.6	637	835	0.4	9.6	8.02	19	1400	26	601	575	0.24	0.05	0.43	0.48	0.07	0.01
T18	Skunk Ck (upper)	04/03/01	1130	01-6026	1.5	259	-------	0.2	11.3	8.35	23	600	59	375	316	0.99	0.88	1.48	2.36	0.63	0.48
T18	Skunk Ck (upper)	04/12/01	1245	01-6078	6.2	645	1010	0.5	-------	7.90	7	280	18	713	695	0.91	0.37	1.13	1.50	0.28	0.22
T18	Skunk Ck (upper)	04/23/01	1130	01-6118	3.5	599	1019	0.5	10.1	8.00	23	2800	32	812	780	0.56	0.19	1.40	1.59	0.28	0.16
T18	Skunk Ck (upper)	05/07/01	1500	01-6134	14.4	903	1133	0.6	7.6	7.82	10	200	11	821	810	0.29	0.12	1.44	1.57	0.13	0.09
T18	Skunk Ck (upper)	06/04/01	1125	01-6173	15.4	1244	1524	0.8	9.7	7.74	21	100	95	1239	1144	0.27	0.30	1.57	1.87	0.26	0.08
T18	Skunk Ck (upper)	06/13/01	1045	01-6903	17.7	931	1081	0.5	8.4	7.92	109	7000	200	1064	864	0.51	0.23	2.11	2.34	0.67	0.23
T18	Skunk Ck (upper)	07/09/01	1145	01-6236	26.4	1560	1521	0.8	7.4	7.97	21	500	106	1214	1108	0.26	0.28	1.63	1.91	0.25	0.13
T18	Skunk Ck (upper)	07/23/01	1000	01-6264	25.9	1315	1306	0.7	15.3	8.22	16	2200	38	1074	1036	0.18	0.09	1.59	1.68	0.25	0.09
T18	Skunk Ck (upper)	08/13/01	1145	01-6928	20.0	865	939	0.5	11.9	7.69	18	1000	36	810	774	0.47	0.12	1.20	1.32	0.16	0.06
T18	Skunk Ck (upper)	09/10/01	1030	01-6354	12.9	701	920	0.5	9.8	7.79	13	900	34	630	596	0.81	0.22	0.52	0.74	0.12	0.04
T18	Skunk Ck (upper)	10/09/01	1130	01-6411	10.0	339	506	0.2	7.6	8.10	10	1600	18	670	652	0.96	0.11	0.43	0.53	0.06	0.01
T19	Colton Creek	06/12/00	1130	00-6130	21.2	1205	1300	0.7	7.3	8.26	40	3600	60	1008	948	0.03	0.15	1.40	1.55	0.28	0.15
T19	Colton Creek	07/13/00	1230	00-6225	26.3	927	903	0.4	4.0	7.57	529	29000	784	1224	440	1.23	0.53	3.83	4.36	1.56	0.23
T19	Colton Creek	08/14/00	1430	00-6268	32.0	1627	-------	0.8	7.5	8.02	348	8700	522	1382	860	1.49	0.28	4.20	4.49	1.22	0.23
T19	Colton Creek	09/18/00	1120	00-6336	18.5	989	1131	0.6	5.8	7.90	30	4600	38	802	764	0.75	0.31	1.09	1.40	0.19	0.11
T19	Colton Creek	10/19/00	1215	00-6400	15.1	836	1030	0.5	6.6	8.36	18	140	8	788	780	0.23	0.08	0.74	0.82	0.10	0.03
T19	Colton Creek	04/03/01	1200	01-6027	3.1	244	420	0.2	10.4	8.23	31	100	56	335	279	1.98	0.54	1.46	2.00	0.69	0.54
T19	Colton Creek	04/12/01	1330	01-6079	7.3	453	685	0.3	-------	7.89	22	3300	50	570	520	2.58	0.28	1.65	1.93	0.63	0.51
T19	Colton Creek	04/23/01	1230	01-6119	3.7	218	369	0.2	10.6	7.90	118	25000	87	303	216	2.19	0.37	1.72	2.09	0.78	0.48
T19	Colton Creek	05/07/01	1400	01-6133	14.1	623	785	0.4	7.3	8.16	25	3700	56	620	564	0.83	0.15	1.38	1.52	0.39	0.28
T19	Colton Creek	06/04/01	1155	01-6174	15.4	891	1093	0.5	11.5	8.05	39	2100	82	854	772	2.55	0.13	1.53	1.66	0.31	0.15
T19	Colton Creek	06/13/01	1115	01-6904	18.0	476	544	0.3	7.4	7.86	255	210000	350	746	396	3.69	0.38	3.39	3.77	1.35	0.68
T19	Colton Creek	07/09/01	1200	01-6237	25.0	1178	1178	0.6	5.3	8.02	586	13000	680	1544	864	2.93	0.37	4.05	4.41	1.39	0.29
T19	Colton Creek	07/23/01	1045	01-6265	25.7	1025	1011	0.5	9.3	8.13	328	38000	423	1131	708	2.58	0.41	3.56	3.97	1.13	0.38
T19	Colton Creek	08/13/01	1215	01-6929	23.9	1006	1028	0.5	15.6	8.46	18	300	29	753	724	2.43	0.09	1.61	1.70	0.16	0.09
T19	Colton Creek	09/10/01	1115	01-6355	15.8	838	996	0.5	16.9	8.40	47	1100	75	715	640	1.05	0.03	2.44	2.47	0.31	0.02
T19	Colton Creek	10/09/01	1200	01-6412	10.9	583	799	0.4	7.2	8.30	48	600	72	856	784	1.60	0.12	1.45	1.57	0.18	0.04
T20	W. Branch Skunk Ck	06/12/00	1215	00-6131	22.7	1599	1672	0.8	5.2	7.96	23	3100	36	1420	1384	0.99	0.12	1.13	1.24	0.18	0.07
T20	W. Branch Skunk Ck	07/13/00	1330	00-6241	28.5	1178	1125	0.4	4.2	7.06	87	2100	138	1099	961	2.15	0.41	2.29	2.70	0.45	0.17
T20	W. Branch Skunk Ck	08/14/00	1515	00-6269	31.5	1565	1355	0.7	16.0	8.76	92	6300	180	1244	1064	0.07	0.11	4.51	4.62	1.00	0.10
T20	W. Branch Skunk Ck	09/18/00	1145	00-6337	18.8	1173	1330	0.7	9.0	7.75	10	950	21	1089	1068	0.28	0.14	0.71	0.84	0.13	0.05
T20	W. Branch Skunk Ck	10/19/00	1245	00-6401	15.6	867	1062	0.5	8.9	8.11	11	80	2	1074	1072	0.53	0.09	0.54	0.63	0.06	0.02
T20	W. Branch Skunk Ck	04/03/01	1220	01-6028	2.9	326	564	0.2	8.5	8.01	32	840	64	472	408	1.42	0.60	1.47	2.06	0.62	0.49
T20	W. Branch Skunk Ck	04/12/01	1415	01-6080	6.8	551	846	0.4		7.89	35	15000	71	691	620	1.63	0.84	1.97	2.81	0.70	0.52
T20	W. Branch Skunk Ck	04/23/01	1300	01-6120	3.7	317	532	0.3	10.2	7.73	103	43000	68	320	252	1.51	0.63	1.73	2.36	0.75	0.46
T20	W. Branch Skunk Ck	05/07/01	1315	01-6132	13.2	1096	1417	0.7	8.1	9.12	15	160000	27	1187	1160	0.86	0.61	1.83	2.44	0.67	0.54
T20	W. Branch Skunk Ck	06/04/01	1230	01-6175	15.9	1143	1385	0.7	13.2	8.12	13	800	29	1121	1092	0.95	0.13	1.26	1.39	0.32	0.26
T20	W. Branch Skunk Ck	06/13/01	1230	01-6905	18.7	815	926	0.5	6.4	7.83	136	37000	334	1102	768	3.06	0.37	3.23	3.60	1.98	0.37
T20	W. Branch Skunk Ck	07/09/01	1300	01-6238	26.7	1478	1432	0.7	10.5	8.08	10	900	25	1145	1120	1.12	0.21	0.97	1.18	0.18	0.11
T20	W. Branch Skunk Ck	07/23/01	1115	01-6266	27.4	1327	1268	0.6	12.4	8.08	16	4400	32	996	964	0.80	0.26	1.40	1.66	0.31	0.19

T20	W. Branch Skunk Ck	08/13/01	1345	01-6930	24.4	1360	1387	0.7	14.2	8.18	13	1200	30	1218	1188	1.80	0.05	1.06	1.10	0.17	0.10
T20	W. Branch Skunk Ck	09/10/01	1145	01-6356	18.8	1115	1265	0.6	14.7	8.27	16	1600	31	971	940	1.00	0.05	1.13	1.18	0.19	0.08
T20	W. Branch Skunk Ck	10/09/01	1230	01-6413	12.3	974	1285	0.6	10.2	8.46	8	110	12	960	948	1.27	0.02	0.90	0.92	0.05	0.04
T21	Skunk Ck (middle)	06/12/00	1315	00-6133	22.7	1274	1334	0.7	11.3	8.53	40	500	72	1152	1080	0.05	0.14	2.00	2.15	0.29	0.04
T21	Skunk Ck (middle)	07/10/00	1615	00-6203	30.9	1137	1023	0.5	10.8	8.14	60	510	64	936	872	0.05	0.04	2.53	2.57	0.35	0.04
T21	Skunk Ck (middle)	07/13/00	1400	00-6242	30.3	773	843	0.4	8.0	7.03	154	1700	246	778	532	0.89	0.12	2.94	3.06	0.67	0.10
T21	Skunk Ck (middle)	08/14/00	1530	00-6270	32.0	1155	1028	0.6	11.7	8.57	43	100	94	810	716	0.04	0.22	2.29	2.51	0.42	0.01
T21	Skunk Ck (middle)	09/18/00	1220	00-6338	18.8	963	1092	0.5	9.5	8.04	29	60	47	923	876	0.06	0.07	1.30	1.36	0.21	0.06
T21	Skunk Ck (middle)	10/19/00	1330	00-6402	15.3	838	1023	0.5	10.9	8.28	35	60	40	780	740	0.15	0.05	0.78	0.83	0.15	0.04
T21	Skunk Ck (middle)	03/21/01	1030	01-6001	0.1	256	-------	0.2	9.9	7.55	30	1300	58	378	320	1.16	2.30	2.84	5.14	0.79	0.57
T21	Skunk Ck (middle)	04/03/01	1240	01-6029	4.1	278	462	0.2	7.3	8.12	70	100	212	496	284	1.41	0.83	2.03	2.86	0.81	0.48
T21	Skunk Ck (middle)	04/12/01	1500	01-6081	6.6	541	836	0.4	-------	7.95	69	16000	209	864	655	1.37	0.48	2.07	2.56	0.83	0.41
T21	Skunk Ck (middle)	04/23/01	1400	01-6121	3.2	370	634	0.3	9.7	7.86	232	28000	69	321	252	1.25	0.53	2.09	2.62	0.88	0.32
T21	Skunk Ck (middle)	05/07/01	1230	01-6131	12.5	896	1178	0.6	7.9	9.53	14	16000	46	882	836	0.31	0.12	1.12	1.24	0.26	0.17
T21	Skunk Ck (middle)	06/04/01	1300	01-6176	17.0	1178	1391	0.7	12.7	8.20	27	100	64	1144	1080	0.71	0.10	1.39	1.50	0.28	0.12
T21	Skunk Ck (middle)	06/13/01	1300	01-6906	20.3	945	1031	0.5	7.4	8.08	245	106000	378	1222	844	2.27	0.31	2.93	3.24	0.98	0.29
T21	Skunk Ck (middle)	07/09/01	1315	01-6239	27.6	1390	1325	0.7	7.9	8.23	32	310	63	1003	940	1.06	0.06	1.03	1.09	0.22	0.13
T21	Skunk Ck (middle)	07/23/01	1230	01-6267	28.9	1174	1101	0.5	15.3	8.42	42	1700	91	863	772	0.43	0.00	1.46	1.46	2.55	0.07
T21	Skunk Ck (middle)	08/13/01	1400	01-6931	25.7	950	939	0.5	13.9	8.65	33	100	80	776	696	0.05	0.02	1.63	1.65	0.24	0.07
T21	Skunk Ck (middle)	09/10/01	1215	01-6357	19.1	879	990	0.5	17.3	8.55	24	180	44	752	708	0.07	0.02	1.23	1.24	0.16	0.03
T21	Skunk Ck (middle)	10/09/01	1300	01-6414	12.8	721	945	0.5	10.9	8.46	21	110	32	704	672	0.33	0.03	0.74	0.77	0.10	0.02
T22	Willow Creek	06/12/00	1230	00-6132	21.8	827	880	0.4	6.3	8.09	31	700	49	577	528	1.80	0.31	1.21	1.52	0.23	0.13
T22	Willow Creek	07/10/00	1645	00-6204	29.7	819	750	0.4	6.3	7.25	31	6500	62	530	468	2.04	0.20	1.71	1.91	0.31	0.22
T22	Willow Creek	07/13/00	1430	00-6243	28.1	702	663	0.3	5.2	6.91	97	3000	142	522	380	2.14	0.36	3.24	3.60	0.82	0.52
T22	Willow Creek	08/14/00	1600	00-6271	32.0	1007	886	0.7	5.7	8.04	50	770	100	632	532	1.75	0.20	1.73	1.92	0.58	0.37
T22	Willow Creek	09/18/00	1240	00-6339	20.0	706	780	0.4	4.1	7.07	101	70	112	616	504	0.09	0.56	1.04	1.60	0.40	0.17
T22	Willow Creek	10/19/00	1340	00-6403	16.8	679	801	0.4	9.2	7.94	11	180	8	444	436	3.10	0.10	0.54	0.64	0.11	0.06
T22	Willow Creek	04/03/01	1305	01-6030	5.4	303	484	0.2	7.6	8.33	24	60	92	376	284	2.74	0.67	1.72	2.41	0.53	0.40
T22	Willow Creek	04/12/01	1545	01-6082	9.4	500	713	0.4	-------	7.93	24	2800	53	483	430	2.24	0.41	1.74	2.15	0.42	0.33
T22	Willow Creek	04/23/01	1445	01-6122	5.2	248	403	0.2	10.1	7.95	78	36000	40	330	290	2.07	0.44	1.69	2.13	0.62	0.36
T22	Willow Creek	05/07/01	1200	01-6130	12.8	479	625	0.3	7.3	7.73	29	17000	54	450	396	1.21	0.16	1.47	1.63	0.42	0.29
T22	Willow Creek	06/04/01	1320	01-6177	16.1	721	868	0.4	18.3	8.34	7	500	10	586	576	2.07	0.09	0.89	0.98	0.12	0.09
T22	Willow Creek	06/13/01	1345	01-6907	19.5	370	413	0.2	6.4	7.72	469	60000	408	696	288	2.80	0.39	3.27	3.66	1.22	0.35
T22	Willow Creek	07/09/01	1345	01-6240	24.8	866	869	0.4	6.6	8.04	48	1400	69	593	524	5.05	0.26	1.56	1.81	0.27	0.13
T22	Willow Creek	07/23/01	1300	01-6268	26.7	656	636	0.3	9.5	8.06	66	16000	103	455	352	2.58	0.25	2.02	2.27	0.59	0.36
T22	Willow Creek	08/13/01	1430	01-6932	25.5	838	830	0.4	10.6	8.25	30	300	44	548	504	4.34	0.07	1.11	1.17	0.22	0.15
T22	Willow Creek	09/10/01	1245	01-6358	18.8	650	739	0.4	11.1	7.94	44	1100	54	434	380	2.06	0.16	1.13	1.29	0.19	0.09
T22	Willow Creek	10/09/01	1330	01-6415	14.4	308	389	0.2	11.2	8.16	18	120	22	466	444	2.26	0.02	0.58	0.61	0.15	0.07
T23	Skunk Creek (lower)	06/12/00	1345	00-6134	23.1	1227	1271	0.6	8.3	8.31	45	800	69	1089	1020	0.04	0.11	1.92	2.03	0.25	0.03
T23	Skunk Creek (lower)	07/10/00	1545	00-6202	29.7	1033	935	0.5	13.0	7.97	51	3200	41	857	816	0.09	0.06	2.26	2.32	0.30	0.03
T23	Skunk Creek (lower)	07/13/00	1530	00-6244	30.0	732	-------	0.3	7.5	7.55	127	1200	186	594	408	1.06	0.21	2.75	2.96	0.54	0.12
T23	Skunk Creek (lower)	08/14/00	1630	00-6272	31.0	1128	1056	0.5	13.2	8.17	27	400	59	867	808	0.07	0.15	1.77	1.91	0.29	0.01
T23	Skunk Creek (lower)	09/18/00	1400	00-6342	19.9	1060	1175	0.6	6.3	7.71	26	50	40	820	780	0.04	0.08	2.36	2.44	0.16	0.04
T23	Skunk Creek (lower)	10/19/00	1400	00-6404	16.4	863	1033	0.5	10.0	8.08	39	40	36	816	780	0.20	0.14	0.81	0.95	0.13	0.01
T23	Skunk Creek (lower)	03/21/01	1115	01-6004	0.4	2082	-------	0.2	10.6	7.51	38	440	86	306	220	1.00	1.70	2.27	3.98	0.70	0.52
T23	Skunk Creek (lower)	04/03/01	1330	01-6031	5.1	289	466	0.2	6.5	8.15	71	90	173	487	314	1.57	0.83	1.90	2.73	0.74	0.44
T23	Skunk Creek (lower)	04/12/01	1615	01-6083	7.3	537	813	0.4	-------	7.96	78	7100	198	818	620	1.48	0.45	1.89	2.34	0.69	0.36
T23	Skunk Creek (lower)	04/23/01	1545	01-6123	4.3	351	582	0.3	9.9	7.66	249	26000	154	486	332	1.34	0.55	2.15	2.70	0.83	0.28
T23	Skunk Creek (lower)	05/07/01	1130	01-6129	13.3	864	1120	0.6	5.9	7.71	28	15000	79	859	780	0.57	0.15	1.72	1.87	0.34	0.19

T23	Skunk Creek (lower)	06/04/01	1400	01-6178	16.9	1147	1357	0.7	13.0	8.22	23	300	58	1102	1044	0.84	0.06	1.28	1.34	0.25	0.11
T23	Skunk Creek (lower)	06/13/01	1500	01-6910	22.7	858	898	0.4	6.5	7.99	617	134000	684	1428	744	2.22	0.25	4.25	4.50	1.55	0.23
T23	Skunk Creek (lower)	07/09/01	1415	01-6241	27.6	1353	1291	0.6	7.0	8.16	26	100	44	1024	980	1.26	0.06	0.90	0.96	0.20	0.14
T23	Skunk Creek (lower)	07/23/01	1315	01-6269	27.8	981	931	0.5	12.9	8.23	53	4600	93	789	696	1.03	0.10	1.56	1.66	0.25	0.07
T23	Skunk Creek (lower)	08/13/01	1500	01-6933	25.8	929	914	0.4	16.0	8.78	41	100	94	794	700	0.05	0.04	2.01	2.04	0.25	0.05
T23	Skunk Creek (lower)	09/10/01	1330	01-6359	20.7	945	1034	0.5	14.9	8.35	27	40	65	759	694	0.06	0.08	1.47	1.55	0.20	0.03
T23	Skunk Creek (lower)	10/09/01	1500	01-6418	14.4	906	1146	0.6	11.4	7.77	23	80	30	874	844	0.33	0.23	0.92	1.15	0.10	0.01
T24	Silver Creek	04/02/01	1315	01-6018	2.4	-------	-------	0.1	8.6	7.81	25	40	37	209	172	1.45	0.76	1.50	2.26	0.63	0.52
T24	Silver Creek	04/12/01	1020	01-6062	6.5	323	499	0.2	6.7	7.81	22	6000	26	318	292	1.86	0.26	1.39	1.65	0.48	0.39
T24	Silver Creek	04/23/01	1315	01-6103	4.5	157	258	0.1	3.5	-------	84	17000	78	283	205	1.15	0.30	1.44	1.74	0.61	0.36
T24	Silver Creek	05/07/01	1250	01-6146	13.8	535	682	0.3	7.1	8.09	3	800	3	431	428	0.95	0.11	1.02	1.13	0.21	0.18
T24	Silver Creek	06/05/01	1200	01-6187	14.9	654	810	0.4	4.4	7.70	3	<100	1	505	504	0.18	0.13	0.82	0.95	0.30	0.26
T24	Silver Creek	06/13/01	1240	01-6207	18.8	311	353	0.2	4.6	7.98	566	22000	270	490	220	1.53	0.50	2.52	3.03	1.19	0.33
T24	Silver Creek	07/09/01	1200	01-6249	25.4	836	836	0.4	8.5	7.68	8	340	3	491	488	0.37	0.11	0.78	0.89	0.09	0.32
T24	Silver Creek	07/23/01	1140	01-6279	27.0	771	742	0.4	6.2	7.72	3	1800	3	467	464	0.08	0.08	0.98	1.07	0.49	0.44
T24	Silver Creek	08/14/01	1125	01-6949	18.3	741	850	0.4	4.4	7.64	6	30	4	604	600	0.09	0.09	1.51	1.61	0.43	0.35
T24	Silver Creek	09/11/01	1200	01-6368	16.8	707	843	0.4	8.5	7.76	4	210	5	537	532	0.03	0.10	0.69	0.79	0.69	0.65
T24	Silver Creek	10/10/01	1215	01-6435	13.3	480	620	0.3	7.8	8.57	10	150	70	854	784	0.08	0.18	2.96	3.14	1.06	0.71
T25	Slip-up Creek	06/14/00	1445	00-6171	17.3	743	813	0.4	7.4	8.56	22	3200	33	585	552	5.73	0.12	1.45	1.57	0.17	0.07
T25	Slip-up Creek	07/10/00	1300	00-3196	25.3	302	307	0.1	5.8	7.37	446	59000	438	646	208	1.80	0.31	3.20	3.50	1.11	0.23
T25	Slip-up Creek	08/16/00	1320	00-6293	20.2	798	878	0.4	10.6	8.05	42	5200	94	674	580	4.86	0.09	1.96	2.05	0.36	0.10
T25	Slip-up Creek	09/19/00	1300	00-6348	17.4	708	829	0.4	11.3	7.98	8	4200	17	533	516	3.49	0.18	1.46	1.64	0.12	0.05
T25	Slip-up Creek	10/19/00	1330	00-6379	11.9	560	747	0.4	-------	8.47	16	2100	13	557	544	3.12	0.07	2.41	2.48	0.28	0.04
T25	Slip-up Creek	03/21/01	1330	01-6007	0.1	189	-------	0.2	10.5	7.78	31	860	84	256	172	2.98	1.79	2.49	4.28	1.15	0.98
T25	Slip-up Creek	04/02/01	1255	01-6017	2.5	195	342	0.2	7.4	7.92	112	110	358	578	220	2.42	0.65	2.36	3.02	0.85	0.34
T25	Slip-up Creek	04/12/01	955	01-6061	5.0	269	436	0.2	3.9	8.32	102	6200	374	622	248	3.56	0.45	2.82	3.27	1.03	0.40
T25	Slip-up Creek	04/23/01	1300	01-6102	3.1	123	211	1.0	3.1	-------	283	21000	412	642	230	2.66	0.54	2.89	3.44	1.17	0.33
T25	Slip-up Creek	05/07/01	1230	01-6145	12.5	390	512	0.2	8.1	8.06	128	13000	182	438	256	3.23	0.20	2.10	2.31	0.60	0.25
T25	Slip-up Creek	06/05/01	1145	01-6186	13.3	636	819	0.4	14.2	8.40	12	1300	19	547	528	6.13	0.06	1.22	1.28	0.10	0.03
T25	Slip-up Creek	06/13/01	1250	01-6208	18.5	220	251	0.1	7.7	7.39	1586	62000	872	1142	270	3.93	0.76	5.61	6.37	2.29	0.20
T25	Slip-up Creek	07/09/01	1230	01-6250	25.8	878	866	0.4	12.2	8.27	21	1000	43	495	452	7.21	0.06	1.53	0.16	0.04	0.08
T25	Slip-up Creek	07/23/01	1155	01-6280	24.1	367	373	0.2	7.2	7.91	560	29000	892	1136	244	2.62	0.32	5.04	5.36	1.68	0.23
T25	Slip-up Creek	08/14/01	1145	01-6950	19.7	688	765	0.4	11.3	8.32	10	1100	28	622	594	6.05	0.07	1.67	1.75	0.11	0.01
T25	Slip-up Creek	09/11/01	1140	01-6367	18.7	752	856	0.4	11.9	8.22	22	1900	53	649	596	5.73	0.11	1.60	1.71	0.14	0.04
T25	Slip-up Creek	10/10/01	1155	01-6434	13.0	611	794	0.4	17.5	8.29	15	1400	24	652	628	6.38	0.05	1.38	1.43	0.09	0.05
T26	W Pipestone Ck (upper)	06/13/00	1500	00-6148	21.9	942	1001	0.5	3.8	8.10	21	7100	30	618	588	0.74	0.33	1.42	1.75	0.40	0.31
T26	W Pipestone Ck (upper)	07/10/00	1100	00-6193	26.1	760	745	0.4	3.3	7.25	148	27000	249	713	464	2.88	0.63	3.00	3.63	1.03	0.42
T26	W Pipestone Ck (upper)	08/16/00	1115	00-6289	18.7	626	781	0.3	6.0	7.80	99	3300	92	592	500	0.09	0.45	2.86	3.31	0.88	0.38
T26	W Pipestone Ck (upper)	04/02/01	1150	01-6014	1.9	96	-------	0.4	9.4	7.56	11	250	16	100	84	1.05	0.94	1.67	2.61	0.78	0.72
T26	W Pipestone Ck (upper)	04/12/01	830	01-6057	4.8	240	390	0.2	7.2	7.82	15	13000	14	282	268	2.17	0.36	1.95	2.31	0.73	0.61
T26	W Pipestone Ck (upper)	04/23/01	1130	01-6098	2.1	81	145	0.0	3.5	-------	133	23000	94	169	75	1.90	0.23	1.86	2.09	0.74	0.47
T26	W Pipestone Ck (upper)	05/07/01	1045	01-6141	12.3	486	641	0.3	7.4	7.77	3	800	4	420	416	1.44	0.14	1.32	1.46	0.27	0.25
T26	W Pipestone Ck (upper)	06/05/01	1040	01-6183	13.3	629	811	0.4	9.0	8.20	7	700	8	556	548	1.38	0.05	1.04	1.10	0.12	0.08
T26	W Pipestone Ck (upper)	06/13/01	1100	01-6204	17.5	301	355	0.2	5.7	8.22	485	14000	228	553	325	9.82	0.45	3.09	3.54	0.78	0.25
T26	W Pipestone Ck (upper)	07/09/01	1045	01-6247	23.3	893	912	0.4	3.4	7.81	31	1100	40	600	560	3.41	0.38	1.66	2.03	0.47	0.35
T26	W Pipestone Ck (upper)	07/23/01	1100	01-6277	21.7	247	264	0.1	6.5	7.53	124	64000	112	288	176	3.95	0.37	2.24	2.61	0.87	0.56
T26	W Pipestone Ck (upper)	08/14/01	1045	01-6947	18.8	816	914	0.5	2.6	7.84	39	1100	62	702	640	3.07	0.28	2.55	2.83	0.69	0.41
T26	W Pipestone Ck (upper)	09/11/01	1045	01-6365	17.1	587	694	0.3	9.5	8.11	38	4400	56	460	404	1.36	0.21	1.35	1.56	0.47	0.28
T26	W Pipestone Ck (upper)	10/10/01	1115	01-6432	12.3	547	723	0.4	8.6	7.98	58	1900	78	514	436	2.61	0.15	1.42	1.57	0.37	0.18

T27	W Pipestone Ck (lower)	06/14/00	1330	00-6169	18.2	671	774	0.4	8.5	8.61	21	3000	44	564	520	2.56	0.08	1.42	1.50	0.23	0.04
T27	W Pipestone Ck (lower)	07/10/00	1230	00-6195	24.4	373	378	0.4	5.3	7.53	175	45000	244	452	208	1.09	0.29	2.33	2.61	0.81	0.34
T27	W Pipestone Ck (lower)	08/16/00	1210	00-6291	19.4	472	528	0.3	13.3	8.48	13	2900	44	368	324	0.83	0.12	2.39	2.51	0.57	0.01
T27	W Pipestone Ck (lower)	09/19/00	1210	00-6347	17.2	593	696	0.3	7.2	7.88	7	5800	12	376	364	1.22	0.04	0.85	0.89	0.09	0.03
T27	W Pipestone Ck (lower)	10/17/00	1230	00-6377	9.9	470	660	0.3	-------	65.00	-------	8400	48	468	420	2.44	0.08	1.51	1.58	0.32	0.04
T27	W Pipestone Ck (lower)	03/21/01	1345	01-6008	0.1	169	-------	0.1	11.9	7.78	32	350	70	250	180	2.00	1.44	2.17	3.61	0.85	0.72
T27	W Pipestone Ck (lower)	04/02/01	1215	01-6015	2.2	120	213	0.1	11.0	7.86	53	390	208	332	124	1.28	0.97	2.30	3.27	1.03	0.69
T27	W Pipestone Ck (lower)	04/12/01	915	01-6059	5.6	280	444	0.2	4.4	7.61	39	16000	177	481	304	3.17	0.40	2.32	2.72	0.88	0.50
T27	W Pipestone Ck (lower)	04/23/01	1215	01-6100	3.1	122	210	0.1	2.5	-------	245	23000	350	525	175	2.06	0.36	2.95	3.31	1.08	0.39
T27	W Pipestone Ck (lower)	05/07/01	1130	01-6143	12.9	513	667	0.3	8.9	8.18	12	1900	33	377	344	2.40	0.14	1.33	1.47	0.26	0.20
T27	W Pipestone Ck (lower)	06/05/01	1115	01-6185	14.1	600	759	0.4	13.4	8.40	9	1800	16	468	452	3.49	0.06	0.91	0.97	0.08	0.01
T27	W Pipestone Ck (lower)	06/13/01	1200	01-6206	17.6	235	274	0.1	7.6	8.13	1912	61000	1088	1303	215	5.49	0.64	7.29	7.93	2.56	0.21
T27	W Pipestone Ck (lower)	07/09/01	930	01-6244	25.6	811	808	0.4	12.1	8.32	24	2500	69	545	476	4.21	0.02	1.53	1.55	0.19	0.12
T27	W Pipestone Ck (lower)	07/23/01	1110	01-6278	24.1	382	389	0.2	6.6	8.04	699	74000	1060	1272	212	2.00	0.37	4.94	5.31	2.06	0.25
T27	W Pipestone Ck (lower)	08/14/01	1115	01-6948	20.3	556	611	0.3	11.7	8.57	17	1000	38	422	384	1.72	0.12	2.19	2.31	0.18	0.02
T27	W Pipestone Ck (lower)	09/11/01	1115	01-6366	17.9	511	591	0.3	12.6	8.50	19	600	47	471	424	1.62	0.04	1.97	2.02	0.20	0.03
T27	W Pipestone Ck (lower)	10/10/01	1145	01-6433	12.3	512	672	0.3	14.6	8.66	22	1900	50	478	428	2.69	0.09	1.99	2.08	0.14	0.02
T28	Pipestone Ck (upper)	06/13/00	1315	00-6145	21.2	1091	1177	0.6	5.1	8.22	36	1800	83	843	760	5.80	0.44	2.36	2.80	0.63	0.38
T28	Pipestone Ck (upper)	07/10/00	950	00-6191	23.7	707	725	0.2	7.5	8.81	12	580	19	571	552	0.85	0.13	1.01	1.14	0.22	0.13
T28	Pipestone Ck (upper)	08/15/00	1545	00-6284	24.3	763	783	0.4	6.0	7.80	41	6000	57	587	530	0.72	0.15	1.29	1.45	0.41	0.25
T28	Pipestone Ck (upper)	09/19/00	1000	00-6343	17.3	669	791	0.4	6.4	7.87	31	1400	46	502	456	0.25	0.13	0.90	0.51	0.19	0.10
T28	Pipestone Ck (upper)	10/17/00	1010	00-6373	8.4	1263	1850	0.9	-------	8.22	18	1400	15	1043	1028	1.68	0.27	1.73	2.00	0.15	0.04
T28	Pipestone Ck (upper)	04/02/01	1030	01-6011	0.4	133	-------	0.1	10.7	7.4	19	180	29	201	172	1.94	1.60	1.84	3.44	0.84	0.74
T28	Pipestone Ck (upper)	04/12/01	715	01-6054	4.9	383	627	0.3	6.2	7.90	27	4000	64	508	444	3.99	0.52	1.75	2.27	0.60	0.44
T28	Pipestone Ck (upper)	04/23/01	1000	01-6096	1.8	168	-------	0.1	5.6	8.20	222	13000	200	405	205	3.00	0.37	2.38	2.75	0.76	0.33
T28	Pipestone Ck (upper)	05/07/01	940	01-6139	11.8	511	684	0.3	7.5	8.24	23	1800	28	500	472	5.49	0.19	1.60	1.79	0.28	0.21
T28	Pipestone Ck (upper)	06/05/01	945	01-6179	13.5	733	940	0.5	10.6	8.60	17	1000	34	694	660	6.11	0.11	1.95	2.06	0.50	0.34
T28	Pipestone Ck (upper)	06/13/01	900	01-6199	16.8	553	656	0.3	6.7	8.64	209	25000	284	779	495	5.52	0.46	2.83	3.29	0.98	0.33
T28	Pipestone Ck (upper)	07/09/01	1000	01-6245	23.9	912	931	0.5	7.4	8.21	17	800	52	628	576	6.63	0.09	1.49	1.58	0.15	0.27
T28	Pipestone Ck (upper)	07/23/01	930	01-6274	25.2	728	727	0.4	7.1	8.44	33	17000	67	515	448	3.72	0.14	1.07	1.20	0.27	0.16
T28	Pipestone Ck (upper)	08/14/01	930	01-6944	19.5	606	677	0.3	5.7	8.22	40	2400	90	608	518	2.20	0.06	1.55	1.60	0.26	0.03
T28	Pipestone Ck (upper)	09/11/01	930	01-6362	15.8	591	717	0.4	11.2	8.12	52	1600	68	512	444	2.30	0.18	1.26	1.43	0.26	0.09
T28	Pipestone Ck (upper)	10/10/01	1000	01-6429	13.3	1102	1410	0.7	14.4	8.35	26	5100	31	863	832	2.72	0.71	1.64	2.35	0.58	0.39
T29	Pipestone Ck (lower)	06/13/00	1345	00-6146	21.9	964	1034	0.5	6.0	8.36	49	1300	103	763	660	5.33	0.04	1.77	1.81	0.44	0.14
T29	Pipestone Ck (lower)	07/10/00	1030	00-6192	26.1	606	621	0.3	8.1	8.20	27	1600	45	469	424	0.15	0.07	1.00	1.07	0.19	0.06
T29	Pipestone Ck (lower)	08/16/00	1020	00-6286	18.8	525	647	0.3	9.3	8.09	21	310	29	526	497	0.12	0.07	1.47	1.54	0.51	0.13
T29	Pipestone Ck (lower)	09/19/00	1030	00-6344	16.2	660	792	0.4	7.5	7.91	23	1500	37	497	460	0.12	0.05	1.15	1.20	0.19	0.05
T29	Pipestone Ck (lower)	10/17/00	1045	00-6374	9.5	513	727	0.4	-------	8.27	9	120	11	479	468	0.46	0.01	0.60	0.60	0.09	0.03
T29	Pipestone Ck (lower)	04/02/01	1110	01-6012	0.7	114	-------	0.1	11.2	7.44	19	130	49	201	152	1.55	0.97	1.76	2.73	0.81	0.72
T29	Pipestone Ck (lower)	04/12/01	735	01-6055	5.3	326	527	0.3	5.9	8.11	31	5700	80	404	324	3.13	0.43	1.85	2.28	0.59	0.47
T29	Pipestone Ck (lower)	04/23/01	1100	01-6097	1.5	138	-------	0.1	5.4	-------	174	29000	132	332	200	2.60	0.25	2.25	2.50	0.67	0.34
T29	Pipestone Ck (lower)	05/07/01	1015	01-6140	12.5	599	788	0.4	5.7	8.01	23	1900	42	590	548	3.99	0.09	1.63	1.72	0.28	0.20
T29	Pipestone Ck (lower)	06/05/01	1030	01-6182	14.0	668	845	0.4	12.4	8.50	11	400	15	527	512	6.09	0.03	1.19	1.22	0.18	0.14
T29	Pipestone Ck (lower)	06/13/01	1000	01-6202	17.3	518	606	0.3	7.0	8.61	187	5000	156	536	380	6.37	0.22	2.19	2.42	0.54	0.21
T29	Pipestone Ck (lower)	07/09/01	1030	01-6246	25.3	916	910	0.4	8.8	8.23	25	560	58	666	608	6.28	0.06	1.30	1.36	0.28	0.20
T29	Pipestone Ck (lower)	07/23/01	1030	01-6275	24.7	587	590	0.3	8.0	8.20	74	4000	123	511	388	3.19	0.15	1.49	1.64	0.44	0.25
T29	Pipestone Ck (lower)	08/14/01	1000	01-6945	19.9	620	687	0.3	7.7	8.39	32	420	58	522	464	0.68	0.03	1.32	1.35	0.18	0.01
T29	Pipestone Ck (lower)	09/11/01	1000	01-6363	16.1	606	729	0.4	14.4	8.38	56	400	74	546	472	0.69	0.07	1.45	1.52	0.24	0.05
T29	Pipestone Ck (lower)	10/10/01	1030	01-6430	12.1	511	679	0.3	15.4	8.39	19	390	27	433	406	1.60	0.06	0.87	0.93	0.12	0.02

T30	Split Rock Ck (upper)	06/13/00	1430	00-6147	21.2	797	860	0.4	5.4	8.40	70	4500	92	672	580	5.69	0.07	1.80	1.87	0.30	0.08
T30	Split Rock Ck (upper)	07/10/00	1130	00-6194	25.3	490	493	0.4	5.8	7.43	131	13000	156	480	324	0.84	0.13	2.10	2.22	0.49	0.13
T30	Split Rock Ck (upper)	08/16/00	1130	00-6290	20.3	493	543	0.3	9.8	8.16	78	800	106	422	316	0.05	0.08	2.80	2.88	0.44	0.04
T30	Split Rock Ck (upper)	09/19/00	1115	00-6345	17.1	522	615	0.3	7.1	7.91	24	5500	67	403	336	0.21	0.08	1.25	1.33	0.18	0.02
T30	Split Rock Ck (upper)	10/17/00	1145	00-6375	10.4	439	608	0.3	-------	8.32	5	250	4	344	340	0.49	0.04	0.58	0.61	0.10	0.02
T30	Split Rock Ck (upper)	04/02/01	1135	01-6013	1.9	120	-------	0.1	8.4	7.69	43	360	86	198	112	1.50	0.90	2.61	3.51	0.85	0.59
T30	Split Rock Ck (upper)	04/12/01	900	01-6058	6.2	309	482	0.2	6.2	7.53	33	1700	130	398	268	3.45	0.32	1.73	2.05	0.55	0.35
T30	Split Rock Ck (upper)	04/23/01	1145	01-6099	2.9	148	255	0.1	3.5	7.00	242	17000	218	348	130	2.70	0.42	2.52	2.94	0.82	0.27
T30	Split Rock Ck (upper)	05/07/01	1110	01-6142	12.9	487	635	0.3	7.6	7.69	38	1300	61	493	432	3.88	0.13	1.46	1.59	0.31	0.18
T30	Split Rock Ck (upper)	06/05/01	1100	01-6184	14.2	625	787	0.4	13.0	8.50	10	400	20	528	508	4.85	0.02	1.16	1.19	0.14	0.07
T30	Split Rock Ck (upper)	06/13/01	1120	01-6205	17.4	345	405	0.2	7.0	8.26	1430	36000	912	1202	290	5.16	0.70	6.71	7.41	2.20	0.20
T30	Split Rock Ck (upper)	07/09/01	1100	01-6248	25.8	853	840	0.4	7.6	8.18	29	400	60	644	584	5.23	0.04	1.25	1.30	0.25	0.14
T30	Split Rock Ck (upper)	07/23/01	1045	01-6276	26.0	647	634	0.3	8.6	8.32	60	5100	108	512	404	3.15	0.11	1.19	1.30	0.34	0.16
T30	Split Rock Ck (upper)	08/14/01	1030	01-6946	21.1	503	543	0.3	6.9	8.20	50	1800	100	572	472	0.75	0.11	2.14	2.25	2.67	0.01
T30	Split Rock Ck (upper)	09/11/01	1030	01-6364	17.8	549	636	0.3	11.3	8.50	47	1400	81	493	412	0.95	0.06	1.47	1.53	0.19	0.03
T30	Split Rock Ck (upper)	10/10/01	1100	01-6431	12.2	504	668	0.3	16.7	8.41	30	580	57	513	456	1.65	0.06	1.44	1.50	0.14	0.02
T31	Split Rock Ck (lower)	06/14/00	1415	00-6170	18.8	791	897	0.4	5.2	8.50	40	4400	91	691	600	4.11	0.09	1.55	1.64	0.28	0.05
T31	Split Rock Ck (lower)	07/10/00	1330	00-6198	26.3	474	463	0.2	5.6	7.99	187	1000	182	438	256	0.89	0.20	2.38	2.58	0.67	0.21
T31	Split Rock Ck (lower)	08/16/00	1300	00-6292	20.6	481	525	0.3	9.0	8.25	31	1100	53	361	308	0.26	0.12	2.07	2.20	0.55	0.02
T31	Split Rock Ck (lower)	09/19/00	1345	00-6350	17.7	547	635	0.3	5.9	8.27	14	1600	23	399	376	1.25	0.10	1.10	1.20	0.36	0.04
T31	Split Rock Ck (lower)	10/17/00	1410	00-6380	13.2	463	604	0.3	-------	8.50	18	330	30	391	361	1.23	0.04	1.10	1.14	0.16	0.01
T31	Split Rock Ck (lower)	04/02/01	1245	01-6016	1.9	123	-------	0.1	10.5	8.15	124	420	316	464	148	1.65	0.97	2.70	3.67	1.05	0.50
T31	Split Rock Ck (lower)	04/12/01	935	01-6060	6.6	308	474	0.2	4.4	7.91	37	9000	148	444	296	3.61	0.38	2.04	2.42	0.69	0.43
T31	Split Rock Ck (lower)	04/23/01	1245	01-6101	3.1	140	224	0.1	3.5	-------	419	15000	616	811	195	2.68	0.56	3.73	4.28	1.42	0.20
T31	Split Rock Ck (lower)	05/07/01	1210	01-6144	13.5	458	586	0.3	8.5	8.11	43	1600	55	311	256	3.79	0.15	1.59	1.74	0.30	0.18
T31	Split Rock Ck (lower)	06/05/01	1230	01-6188	15.0	579	716	0.4	10.4	8.40	9	800	16	496	480	4.31	0.06	1.23	1.29	0.07	0.02
T31	Split Rock Ck (lower)	06/13/01	1320	01-6209	18.8	319	362	0.2	6.8	7.72	1536	137000	972	1277	305	4.14	0.68	6.40	7.08	2.54	0.21
T31	Split Rock Ck (lower)	07/09/01	1245	01-6251	26.8	839	812	0.4	10.2	8.34	25	1400	60	580	520	5.15	0.04	1.32	1.36	0.15	0.13
T31	Split Rock Ck (lower)	07/23/01	1215	01-6281	27.8	758	720	0.3	7.2	8.38	22	69000	62	522	460	3.49	0.09	1.22	1.31	0.28	0.15
T31	Split Rock Ck (lower)	08/14/01	1200	01-6951	21.3	449	483	0.2	9.6	9.06	31	1500	94	418	324	0.41	0.11	2.49	2.60	0.24	0.02
T31	Split Rock Ck (lower)	09/11/01	1215	01-6369	19.9	504	558	0.3	14.1	8.83	26	600	63	423	360	0.91	0.06	1.85	1.92	0.20	0.01
T31	Split Rock Ck (lower)	10/10/01	1230	01-6436	12.9	499	649	0.3	13.5	8.68	23	1500	69	445	376	2.00	0.03	1.54	1.57	0.17	0.04
T32	Beaver Ck (upper)	06/12/00	1550	00-6138	25.2	470	510	0.3	9.2	8.17	22	700	49	625	576	5.30	0.02	1.25	1.27	0.18	0.07
T32	Beaver Ck (upper)	07/10/00	1430	00-6200	31.3	764	673	0.4	8.1	7.53	39	20000	125	625	500	2.27	0.04	1.66	1.71	0.29	0.08
T32	Beaver Ck (upper)	08/16/00	1800	00-6302	23.7	741	760	0.4	9.8	8.18	8	700	28	504	476	1.23	0.05	1.20	1.25	0.13	0.03
T32	Beaver Ck (upper)	09/19/00	1415	00-6351	17.7	725	843	0.4	10.7	8.07	7	2000	14	562	548	1.11	0.03	0.63	0.66	0.07	0.02
T32	Beaver Ck (upper)	10/17/00	1500	00-6381	12.7	364	737	0.4	-------	8.22	9	420	14	550	536	1.83	0.05	0.63	0.68	0.08	0.06
T32	Beaver Ck (upper)	03/21/01	1240	01-6006	1.5	270	-------	0.2	8.1	7.60	16	350	16	296	280	2.81	2.61	2.69	5.29	1.19	1.10
T32	Beaver Ck (upper)	04/02/01	1345	01-6019	1.3	140	-------	0.1	10.0	8.03	159	390	436	632	196	2.56	0.90	2.83	3.74	1.12	0.44
T32	Beaver Ck (upper)	04/12/01	1105	01-6064	6.3	300	468	0.2	4.1	7.47	210	8000	710	978	268	6.05	0.61	4.15	4.75	1.39	0.41
T32	Beaver Ck (upper)	04/23/01	1345	01-6104	3.4	134	226	0.1	3.8	-------	666	13000	632	827	195	4.40	0.80	4.88	5.68	1.71	0.29
T32	Beaver Ck (upper)	05/07/01	1330	01-6147	13.4	425	546	0.3	7.3	8.08	164	2100	258	602	344	7.64	0.19	2.19	2.38	0.64	0.20
T32	Beaver Ck (upper)	06/05/01	1300	01-6189	14.0	656	831	0.4	12.3	8.30	11	500	34	588	554	8.17	0.06	1.53	1.59	0.09	0.05
T32	Beaver Ck (upper)	06/13/01	1400	01-6210	19.8	194	215	0.1	7.5	7.34	3057	96000	1580	1770	190	5.21	0.65	10.39	11.04	3.77	0.21
T32	Beaver Ck (upper)	07/09/01	1320	01-6252	25.6	885	877	0.4	10.5	8.21	26	800	74	590	516	8.12	0.04	1.39	1.43	0.13	0.09
T32	Beaver Ck (upper)	07/23/01	1300	01-6282	25.3	588	585	0.3	8.7	8.12	511	65000	819	1215	396	3.80	0.20	4.23	4.43	1.50	0.18
T32	Beaver Ck (upper)	08/14/01	1230	01-6952	18.4	744	850	0.4	10.9	8.27	12	690	30	634	604	5.63	0.05	1.29	1.34	0.14	0.03
T32	Beaver Ck (upper)	09/11/01	1300	01-6370	20.9	761	824	0.4	11.3	8.33	8	160	22	558	536	3.70	0.07	1.02	1.10	0.08	0.04
T32	Beaver Ck (upper)	10/10/01	1300	01-6437	12.3	368	480	0.2	16.8	8.52	9	1000	19	631	612	4.81	0.04	1.41	1.45	0.10	0.07

T33	Beaver Ck (lower)	06/12/00	1530	00-6137	24.3	543	550	0.3	7.8	8.32	20	1300	122	730	608	5.61	0.02	1.42	1.44	0.28	0.08
T33	Beaver Ck (lower)	07/10/00	1450	00-6201	32.0	885	730	0.4	7.4	7.62	73	37000	169	719	550	2.34	0.17	1.89	2.07	0.28	0.06
T33	Beaver Ck (lower)	08/16/00	1700	00-6300	24.0	505	525	0.3	10.1	8.26	15	670	52	508	456	1.18	0.02	1.50	1.52	0.24	0.02
T33	Beaver Ck (lower)	09/19/00	1500	00-6352	18.3	682	778	0.4	9.6	8.17	3	2900	7	519	512	1.22	0.01	0.50	0.50	0.07	0.05
T33	Beaver Ck (lower)	10/17/00	1525	00-6382	13.0	494	640	0.3	9.1	8.42	3	200	3	587	584	1.58	0.02	0.98	1.00	0.05	0.04
T33	Beaver Ck (lower)	03/21/01	1200	01-6005	0.1	188	-------	0.2	11.7	7.83	29	1600	66	254	188	1.92	1.87	2.49	4.35	0.83	0.71
T33	Beaver Ck (lower)	04/02/01	1410	01-6020	1.8	175	-------	0.1	12.0	8.0	304	380	678	882	204	2.85	0.90	3.39	4.29	1.36	0.43
T33	Beaver Ck (lower)	04/12/01	1145	01-6066	6.3	374	571	0.3	1.9	7.60	332	9500	754	1158	404	5.45	0.65	4.73	5.38	1.64	0.38
T33	Beaver Ck (lower)	04/24/01	1210	01-6110	6.2	269	421	0.2	9.4	7.74	580	4300	654	1009	355	6.34	0.47	3.04	3.51	1.23	0.26
T33	Beaver Ck (lower)	05/07/01	1400	01-6148	13.9	460	584	0.3	7.5	7.87	231	4400	364	716	352	7.00	0.20	2.52	2.72	0.76	0.19
T33	Beaver Ck (lower)	06/05/01	1320	01-6190	14.6	659	822	0.4	12.7	8.40	16	800	52	612	560	7.38	0.05	1.09	1.14	0.16	0.07
T33	Beaver Ck (lower)	06/13/01	1445	01-6211	18.5	182	207	0.1	7.2	8.01	3066	172000	1312	1502	190	3.53	0.92	9.01	9.93	3.97	0.30
T33	Beaver Ck (lower)	07/09/01	1400	01-6253	26.7	890	865	0.4	9.5	8.33	29	1200	77	637	560	7.07	0.06	1.43	1.49	0.10	0.07
T33	Beaver Ck (lower)	07/23/01	1315	01-6283	28.0	831	787	0.4	8.5	8.38	71	3400	176	684	508	5.00	0.07	1.35	1.43	0.39	0.11
T33	Beaver Ck (lower)	08/14/01	1300	01-6953	19.8	746	827	0.4	8.9	8.28	17	910	45	641	596	4.98	0.03	1.32	1.35	0.14	0.04
T33	Beaver Ck (lower)	09/11/01	1320	01-6371	20.7	777	846	0.4	10.4	8.35	12	120	30	578	548	3.36	0.04	0.81	0.85	0.11	0.05
T33	Beaver Ck (lower)	10/10/01	1315	01-6438	13.5	665	852	0.4	14.5	8.46	9	580	13	605	592	4.73	0.04	0.83	0.87	0.09	0.05

Appendix C.
WQ Field Datasheet

Central Big Sioux River Watershed Assessment
East Dakota Water Development District
Water Quality Data

Lab No. | Source: Tributary / River
Site Location Code: | Site Name:
Samples Collected By: | Date: Time:
Staff Gage Reading:
Type of Sample: Grab / Time Comp / Depth Integrated | Sample Depth:

Visual Observations
Precipitation – none light moderate heavy
Wind (&direction) – calm moderate strong
Odor – yes no
Septic - yes no
Dead Fish - yes no
Film - yes no
Color -
Width -
Depth -
Ice Cover - yes no

Field Analysis	
Parameter	**Measure**
Water Temperature	
Air Temperature	
Conductivity	
Salintiy	
Dissolved Oxygen	
pH	
Secchi	
Turbidity	

Lab Analysis	**Field Preparation**				
Parameter	Cool to 4ºC	2mL conc H_2SO_4 Cool to 4ºC	2mL conc H_2SO_4 Cool to 4ºC	Filtered, 2mL conc H_2SO_4 Cool to 4ºC	$Na_2S_2O_3$
	Bottle A	Bottle B	Bottle C	Bottle D	Bottle E
Total Solids	XXX				
Total Suspended Solids	XXX				
Ammonia-N		XXX			
Total Kjeldahl-N		XXX			
Nitrate-N		XXX			
Total Phosphorus			XXX		
Total Dissolved Phosphorus				XXX	
Fecal Coliform					XXX

Field Observations:

Appendix D.
Start and End Dates of Stage Recorders

Discharge Recorder Types and Start/End Dates

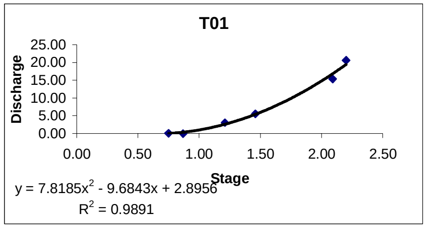
Site Code	Site Name	Starting Date	Ending Date	Recorder Type
T1	No Deer Ck (upper)	08/18/99	11/02/99	Solinst
		03/15/00	10/30/00	Solinst
T2	No Deer Ck (lower)	07/08/99	10/28/99	Stevens
		03/10/00	08/21/00	Stevens
T3	Six Mile Ck (upper)	07/09/99	07/27/99	Stevens
		03/27/00	11/03/00	Stevens
T4	Six Mile Ck (middle)	07/09/99	10/28/99	Stevens
		03/10/00	11/03/00	Stevens
T5	Six Mile Ck (lower)	07/09/99	10/28/99	Stevens
		03/10/00	11/03/00	Stevens
T6	Deer Creek	08/18/99	11/02/99	Solinst
		03/15/00	06/30/00	Solinst
		07/05/00	10/30/00	OTT
T7	Medary Ck (upper)	07/09/99	10/28/99	Stevens
		03/10/00	11/03/00	Stevens
T8	Medary Ck (middle)	07/12/99	10/28/99	Stevens
		03/10/00	11/03/00	Stevens
T9	Medary Ck (lower)	08/18/99	11/02/99	Solinst
		03/15/00	10/30/00	Solinst
T10	Lake Campbell Outlet	03/27/00	11/03/00	Stevens
T11	Spring Creek	07/12/99	10/28/99	Stevens
		03/10/00	11/03/00	Stevens
T12	Flandreau Creek	08/19/99	11/02/99	Solinst
		03/23/00	07/19/00	Solinst
		07/18/00	10/30/00	OTT
T13	Jack Moore Creek	07/12/99	10/28/99	Stevens
		03/10/00	11/03/00	Stevens
T14	Bachelor Creek	04/26/00	11/03/00	Stevens
T15	North Buffalo Creek	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T16	Buffalo Creek	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T17	Brant Lake Outlet	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T18	Skunk Creek (Upper)	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T19	Colton Creek	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T20	W. Branch Skunk Creek	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T21	Skunk Creek (Middle)	07/03/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T22	Willow Creek	07/03/00	10/30/00	OTT

		03/20/01	10/31/01	OTT
T24	Silver Creek	07/17/00	10/30/00	OTT
		03/20/01	10/31/01	OTT
T25	Slip-up Creek	07/17/00	10/31/00	OTT
		03/20/01	10/31/01	OTT
T26	W. Pipestone (Upper)	07/05/00	10/31/00	OTT
		03/20/01	10/31/01	OTT
T27	W. Pipestone (Lower)	07/06/00	10/31/00	OTT
		03/20/01	10/31/01	OTT
T28	Pipestone Creek (Upper)	07/05/00	10/31/00	OTT
		03/20/01	10/31/01	OTT
T29	Pipestone Creek (Lower)	07/06/00	10/31/00	OTT
		03/20/01	10/31/01	OTT
T30	Split Rock Creek (Upper)	07/19/00	10/31/00	Solinst
		03/20/01	10/31/01	Solinst
T31	Split Rock Creek (Lower)	07/19/00	10/31/00	Solinst
		03/20/01	10/31/01	Solinst
T32	Beaver Creek (Upper)	07/03/00	10/31/00	OTT
		03/20/01	10/31/01	OTT
T33	Beaver Creek (Lower)	07/20/00	10/31/00	Solinst
		03/20/01	10/31/01	Solinst

Appendix E.
Stage Discharge Curves

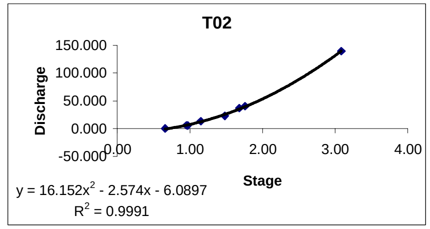
T01

Stage	Discharge
0.75	0.10
0.87	0.02
1.21	3.10
1.46	5.54
2.09	15.32
2.20	20.63



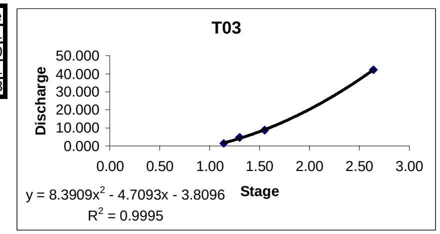
T02

Stage	Discharge
0.66	0.138
0.95	5.694
0.97	5.431
1.15	13.281
1.48	22.982
1.68	36.720
1.76	40.193
3.09	139.525



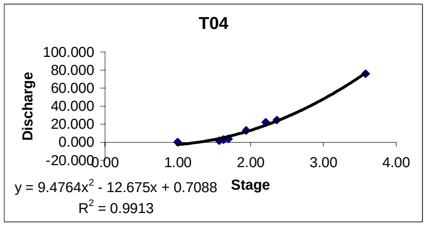
T03

Stage	Discharge
1.14	1.421
1.30	4.810
1.55	8.781
2.64	42.253



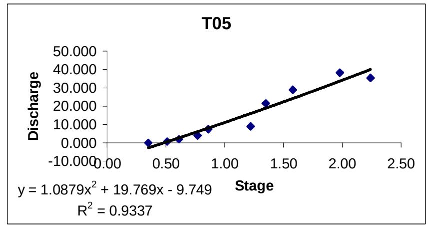
T04

Stage	Discharge
1.00	0.100
1.57	1.703
1.63	2.802
1.70	3.861
1.94	13.051
2.21	22.137
2.36	24.785
3.58	76.039



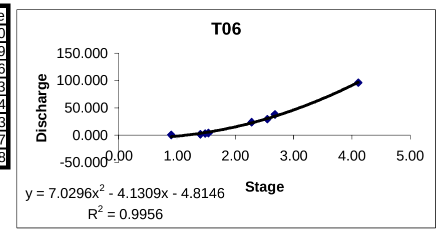
T05

Stage	Discharge
0.35	0.100
0.51	0.716
0.61	1.957
0.77	4.049
0.86	7.539
1.22	9.000
1.35	21.534
1.58	28.965
1.98	38.250
2.24	35.463



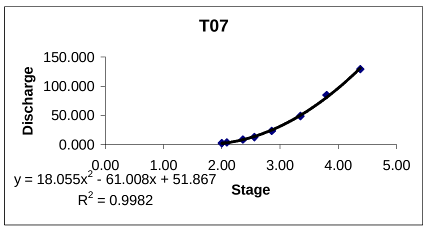
T06

Stage	Discharge
0.90	0.100
1.40	1.359
1.49	2.696
1.54	3.663
2.28	23.624
2.55	29.183
2.68	37.767
4.11	96.228



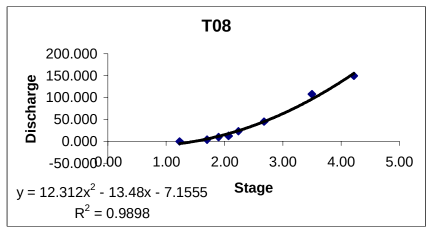
T07

Stage	Discharge
2.00	2.580
2.09	3.796
2.37	8.880
2.56	12.858
2.86	23.518
3.35	49.014
3.80	84.938
4.38	129.236



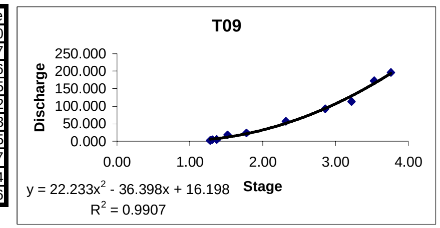
T08

Stage	Discharge
1.23	0.100
1.70	3.887
1.90	9.556
2.07	12.310
2.24	23.089
2.68	44.948
3.50	107.526
4.22	149.614



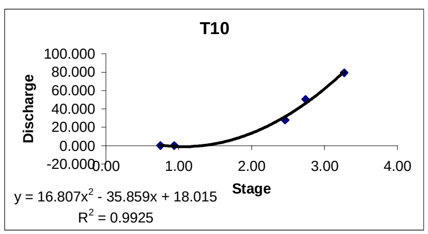
T09

Stage	Discharge
1.28	2.440
1.31	4.697
1.37	5.616
1.52	18.615
1.78	24.012
2.32	57.433
2.86	93.085
3.22	113.417
3.53	172.904
3.76	195.966



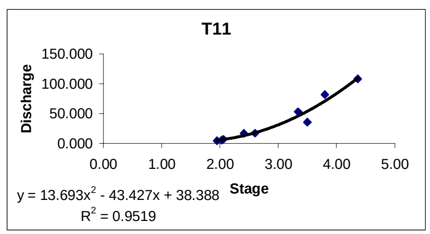
T10

Stage	Discharge
0.75	0.010
0.94	0.030
2.46	27.877
2.74	50.345
3.27	79.390



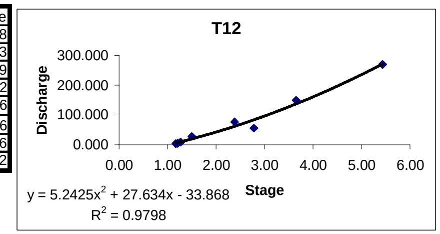
T11

Stage	Discharge
1.95	4.523
2.03	5.905
2.06	7.279
2.41	17.083
2.60	17.372
3.34	53.564
3.50	35.740
3.80	82.023
4.37	108.321



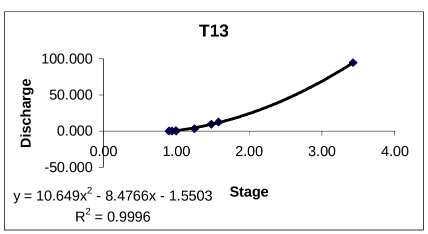
T12

Stage	Discharge
1.17	3.338
1.21	4.513
1.27	8.649
1.50	27.662
2.38	76.216
2.78	55.756
3.65	149.176
5.43	269.312



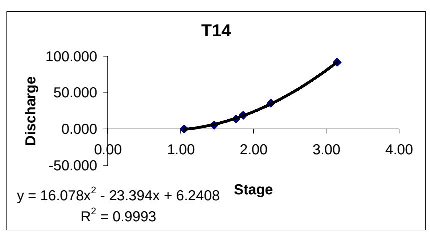
T13

Stage	Discharge
0.90	0.100
0.94	0.122
1.00	0.449
1.00	0.295
1.25	3.208
1.48	9.475
1.58	12.264
3.43	94.625



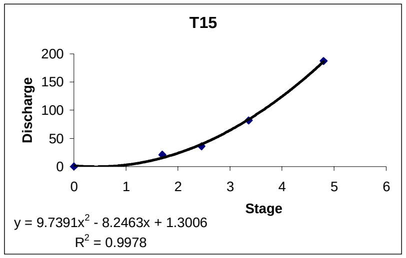
T14

Stage	Discharge
1.05	0.100
1.46	5.284
1.76	13.852
1.86	19.070
2.24	35.431
3.15	91.836



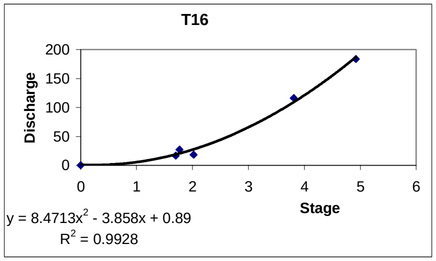
T15

Stage	Discharge
0	0
1.7	20.938
2.45	36.105
3.36	81.648
4.8	187.243



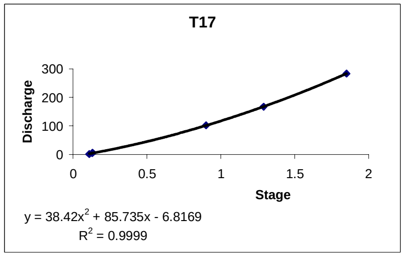
T16

Stage	Discharge
0	0
1.7	16.741
1.77	27.087
2.02	18.408
3.81	116.112
4.92	183.767



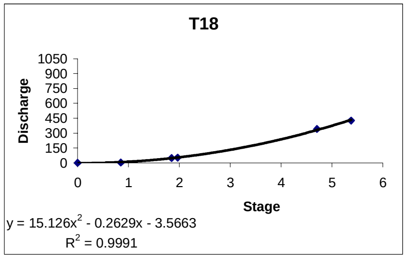
T17

stage	discharge
0.11	1.512
0.13	5.097
0.132	6.612
0.9	101.761
1.29	167.292
1.85	283.421



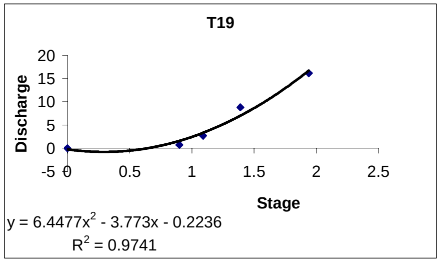
T18

Stage	Discharge
0.85	2.875
1.85	47.743
1.97	52.895
4.71	339.56
5.38	426.407
0	0



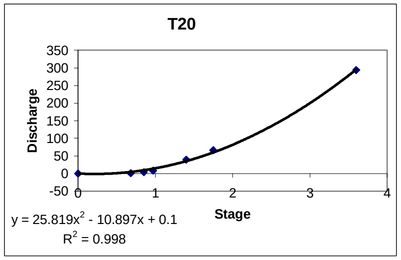
T19

Stage	Discharge
0	0
1.09	2.709
0.9	0.728
1.39	8.807
1.94	16.173



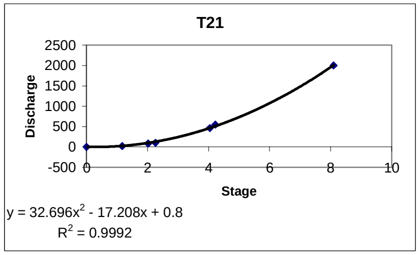
T20

Stage	Discharge
0.85	3.999
0.68	0.992
0.97	8.33
1.75	66.678
1.4	39.603
3.6	294.145
0	0



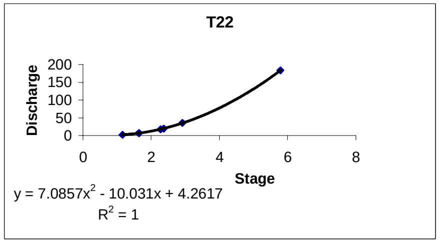
T21

Stage	Discharge
2.26	101.21
2.02	82.486
1.17	18.182
4.22	548.081
8.1	1999.49
4.04	465.931
0	0



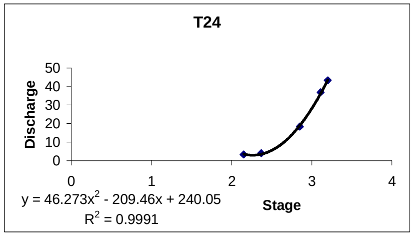
T22

Stage	Discharge
1.16	2.089
1.64	7.241
1.65	7.095
2.28	17.627
2.37	19.987
2.92	35.91
5.79	183.695



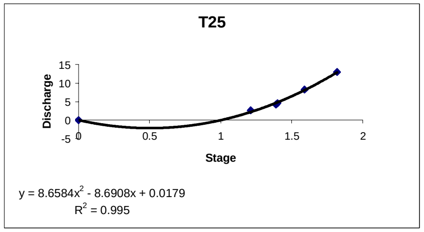
T24

Stage	Discharge
2.15	3.342
2.37	4.079
2.85	18.32
3.11	36.829
3.2	43.335



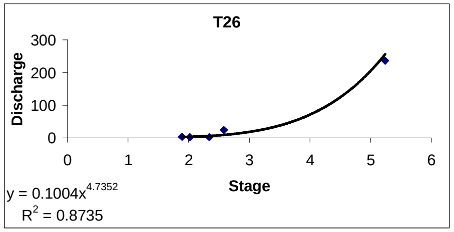
T25

Stage	Discharge
1.211	2.665
1.39	4.2017
1.4	4.6
1.59	8.249
1.82	12.951
0	0



T26

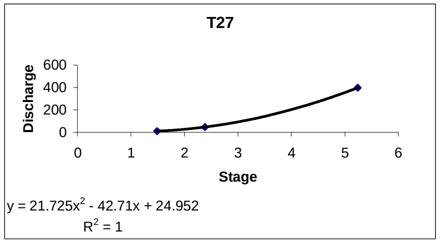
Stage	discharge
2.34	2.178
2.58	23.931
5.24	236.429
2.02	1.957
1.89	3.054



Appendix E

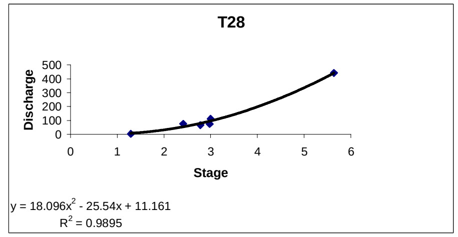
T27

Stage	Discharge
1.49	9.546
2.38	46.362
5.24	397.673



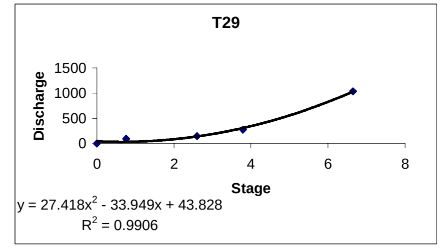
T28

Stage	Discharge
1.29	3.979
2.41	76.465
2.78	67.305
2.98	75.085
3	112.555
5.64	443.574



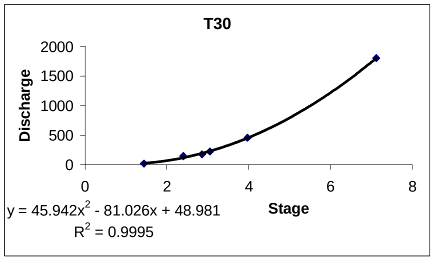
T29

Stage	Discharge
0	0
0.76	94.011
2.6	147.376
3.79	277.866
6.65	1038.88



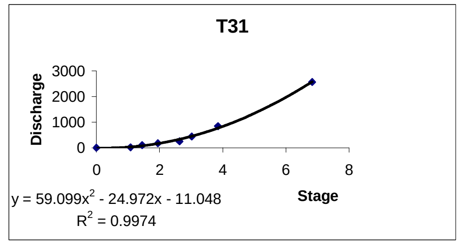
T30

Stage	Discharge
1.44	21.312
2.4	146.2
2.86	175.235
3.05	222.194
3.97	455.322



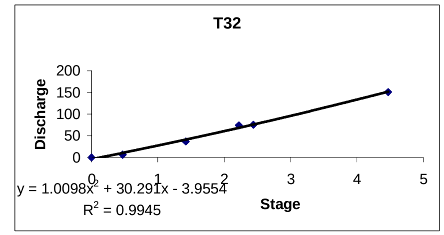
T31

Stage	Discharge
1.08	20.046
1.45	97.407
1.95	173.8
2.63	251.168
3.02	437.304
3.85	846.656
6.83	2564.16
0	0



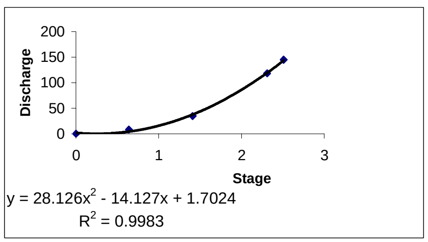
T32

Stage	Discharge
0	0
0.47	6.422
1.42	36.64
2.22	74.086
2.44	75.54
4.47	150.806



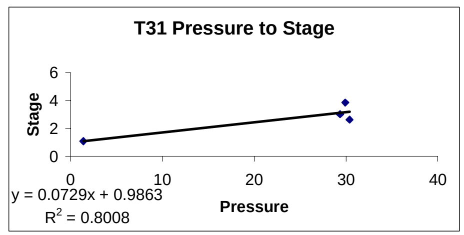
T33

Stage	discharge
0	0
0.64	8.257
1.41	34.812
2.31	118.282
2.51	144.816



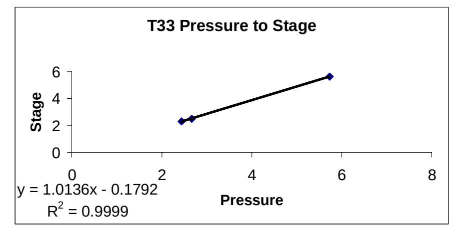
T31

Pressure	Stage
1.39	1.08
29.36	3.02
29.91	3.85
30.39	2.63



T33

Pressure	Stage
2.67	2.51
2.44	2.31
5.73	5.63



Appendix E

Appendix F.
Equations Used to Calculate Discharges

Stream Flow - Stage Relationships

SiteID	Equation	R^2
T01	$y = 7.8185x^2 - 9.6843x + 2.8956$	0.989
T02	$y = 16.152x^2 - 2.574x - 6.0897$	0.999
T03	$y = 8.3909x^2 - 4.7093x - 3.8096$	1.000
T04	$y = 9.4764x^2 - 12.675x + 0.7088$	0.991
T05	$y = 1.0879x^2 + 19.769x - 9.749$	0.934
T06	$y = 7.0296x^2 - 4.1309x - 4.8146$	0.996
T07	$y = 18.055x^2 - 61.008x + 51.867$	0.998
T08	$y = 12.312x^2 - 13.48x - 7.1555$	0.990
T09	$y = 22.233x^2 - 36.398x + 16.198$	0.991
T10	$y = 16.807x^2 - 35.859x + 18.015$	0.993
T11	$y = 13.693x^2 - 43.427x + 38.388$	0.952
T12	$y = 5.2425x^2 + 27.634x - 33.868$	0.980
T13	$y = 10.649x^2 - 8.4766x - 1.5503$	1.000
T14	$y = 16.078x^2 - 23.394x + 6.2408$	0.999
T15	$y = 9.7391x^2 - 8.2463x + 1.3006$	0.998
T16	$y = 8.4713x^2 - 3.858x + 0.89$	0.993
T17	$y = 38.42x^2 + 85.735x - 6.8169$	1.000
T18	$y = 15.126x^2 - 0.2629x - 3.5663$	0.999
T19	$y = 6.4477x^2 - 3.773x - 0.2236$	0.974
T20	$y = 25.819x^2 - 10.897x + 0.1$	0.998
T21	$y = 32.696x^2 - 17.208x + 0.8$	0.999
T22	$y = 7.0857x^2 - 10.031x + 4.2617$	1.000
T23	USGS provided	
T24	$y = 46.273x^2 - 209.46x + 240.05$	0.999
T25	$y = 8.6584x^2 - 8.6908x + 0.0179$	0.995
T26	$y = 0.1004x^{4.7352}$	0.874
T27	$y = 21.751x^2 - 42.909x + 24.952$	1.000
T28	$y = 18.096x^2 - 25.54x + 11.161$	0.990
T29	$y = 27.418x^2 - 33.949x + 43.828$	0.991
T30	$y = 45.942x^2 - 81.026x + 48.981$	1.000
T31	$y = 59.099x^2 - 24.972x - 11.048$	0.997
T32	$y = 1.0098x^2 + 30.291x - 3.9554$	0.995
T33	$y = 28.126x^2 - 14.127x + 1.7024$	0.998
R01	USGS provided	
R02	USGS provided	
R03	USGS provided	
R04	USGS provided	
R05	USGS provided	
R06	USGS provided	
R07	USGS provided	
R08	USGS provided	
R09	USGS provided	
R10	USGS provided	
R11	USGS provided	
R12	USGS provided	
R13	USGS provided	

Appendix G.
Terms and Definitions of the Core Fish Metrics

Terms and Definitions of the Core Fish Metrics

Knowledge of historical indigenous fish distributions can be valuable to selection of candidate metrics. A comparison of recent fish distributions in the Big Sioux River with those summarized in Bailey and Allum (1962) indicate that no loss of species has occurred. All species have been persistent over a documented period of 50 to 60 years. One interesting exception is Bailey and Allum's reporting of the occurrence of mud minnows and red belly dace in a spring-fed tributary to Six Mile Creek. The only documentation of mud minnows in South Dakota occurred in this tributary in January 1947, but the authors did not collect any after three repeated attempts in 1952. They describe these redbelly dace as a remnant population.

Non-indigenous fish introductions and distributions need to be understood before candidate metrics are selected. In some states, non-indigenous introductions have significant effects on the stream ecology. In South Dakota, the distributions of most non-indigenous fishes are minimal. Non-indigenous species, based on recent collections, rarely comprise a significant number or biomass of fishes in samples from headwater and wadable sites.

Climatic and geologic factors influence streamflow patterns and faunal diversity, and therefore, must form part of the basis for metric selection. Stream flow patterns in eastern South Dakota are influenced by cycling of wet and dry phases over 10-20 year periods. During dry phases, headwaters, and quite often, entire tributaries become intermittent. Theoretically, fish community structure and function in these environments are less diverse than communities in perennial stream environments. Additionally, the diversity of the regional fish fauna in the Big Sioux River, which flows to the Missouri River, is lower than regional fish faunas in rivers that flow to the Mississippi River.

The following metrics and their definitions are those recommended to be used when assessing the Midwest region. These metrics weighed heavily on which candidate metrics would be chosen as the core metrics. Though, box plots were used to further differentiate what the overall final core metrics for fishes would be used. After each metric description, the core metric it corresponds to is in parenthesis.

Metric : Total number of fish species
As originally intended this metric has been accepted as an indicator of overall stream health. The most common alternative in warm water streams is number of native fish species, which will be tested. (Core Metric 1 – Total Species Richness, and 2 – Native Minnow Species Richness)

Metric: Number and identity of darter species
Darters represent a diverse taxonomic group that inhabits benthic habitats. These species decline when benthic habitat is subject ed to sedimentation and reduced oxygen. In the Big Sioux River system, only three darters species occur with the blackside darter rarely collected in either historic or recent surveys. Karr suggested that other benthic taxon could replace darters in regions outside the range of darters. Alternative metrics to be tested are number of benthic species, and number of benthic insectivore species. (Core Metric 3 – Benthic Insectivore Richness)

Metric: Number and identity of sunfish species

Sunfishes represent a diverse taxanomic group that inhabits pools. These species decline when pool habitats are degraded and pool cover is reduced. Only two sunfish species are native to the Big Sioux River system. Therefore, alternative metrics must be selected that incorporate a more diverse array of non-benthic species. For headwater sites, the number of headwater species and the proportion of individuals as headwater species were selected for testing. For headwater and wadable sites, the number of minnow species and the number of water column species was tested. (Core Metric 4 – Headwater Species Richness)

Metric: Number and identity of sucker species

Suckers are sensitive to physical and chemical degradation and integrate disturbances over many years because they are long lived (Karr et al. 1986). In headwater and wadable sites of the Big Sioux River system, the white sucker is the only wide spread species, and the shorthead redhorse is occasionally found in very low numbers. An alternative has been number of minnow species, which is listed as an alternative for metric 3. No other taxon in headwater or wadable streams has the multi-year attributes of suckers, but several semelparous minnow species commonly live 3 or 4 years. In prairie streams, if several of these species exhibit three or more discrete size classes, then this could be an indication of a healthy stream. Therefore, the number of semelparous minnow species that exhibit multiple size classes will be tested.

Metric: Number and identity of intolerant species

Intolerant species are the first to be affected by major sources of degradation such as siltation, low dissolved oxygen, reduced flow and chemical contamination. Intolerant designations should compose only 5 to 10% of the fish community and, generally, should represent species found only in streams at or near their natural potential. However, intolerant species may rarely occur in headwaters. An alternative metric for headwater sites is the number of sensitive species (OEPA 1987), which include highly intolerant species and some moderately intolerant species. The number of sensitive species has also been applied to wadable and non-wadable streams. This metric has potential for streams in the Big Sioux River system, because intolerant species in headwaters, and possibly wadable streams during dry years, may naturally become scarce. (Core Metric 6 – Sensitive Species Richness)

Metric: Proportion of individuals as green sunfish

Green sunfish in Midwestern streams were designated by Karr as a species that is tolerant and becomes dominant in the most degraded streams. Karr suggested that other tolerant species that become dominant in degraded conditions can be used as substitutes, or that the proportion of tolerant species can be used to avoid weighting this metric on one species. The latter is frequently selected as a substitute and was chosen as a potential alternative for the Big Sioux River. (Core Metric 7- % Tolerant Species Biomass)

Metric: Proportion of individuals as omnivores

Omnivores increase in streams where the physical and chemical environment becomes degraded. In degraded environments, the food source becomes less reliable, thus giving omnivores an advantage over more specialized species. An alternative is the proportion of total biomass as omnivores, which may be a more sensitive metric in prairie streams that theoretically have fewer semelparous specialists and a simpler trophic structure compared to systems of the original metrics. By measuring biomass of omnivores, biases associated with differentiation of young-of-year from adults at the field level may be ameliorated. (Core Metric 9 - % Omnivore Biomass)

Metric: Proportion of individuals as insectivorous minnows
Insectivores decrease in streams where the physical and chemical environments become degraded, because the invertebrate food base becomes less reliable. An alternative is the proportion of total biomass as insectivorous minnows. For the same reason given for metric 7, biomass may be a more sensitive metric in prairie streams. (Core Metric 8 - % Insectivorous Minnows)

Metric: Proportion of individuals as piscivores
This metric represents the upper trophic level in streams. However, in prairie streams of the Big Sioux River system, piscivores are not as diverse as streams that flow into the Mississippi River. Headwater streams and wadable streams do not typically support a persistent adult piscivore assemblage. In contrast, they often support a persistent assemblage of pioneer species, which may indicate either unstable or degraded conditions. The proportion of pioneering was selected as an alternative metric for headwater and wadable streams. (Core Metric 5 - % Pioneering Species)

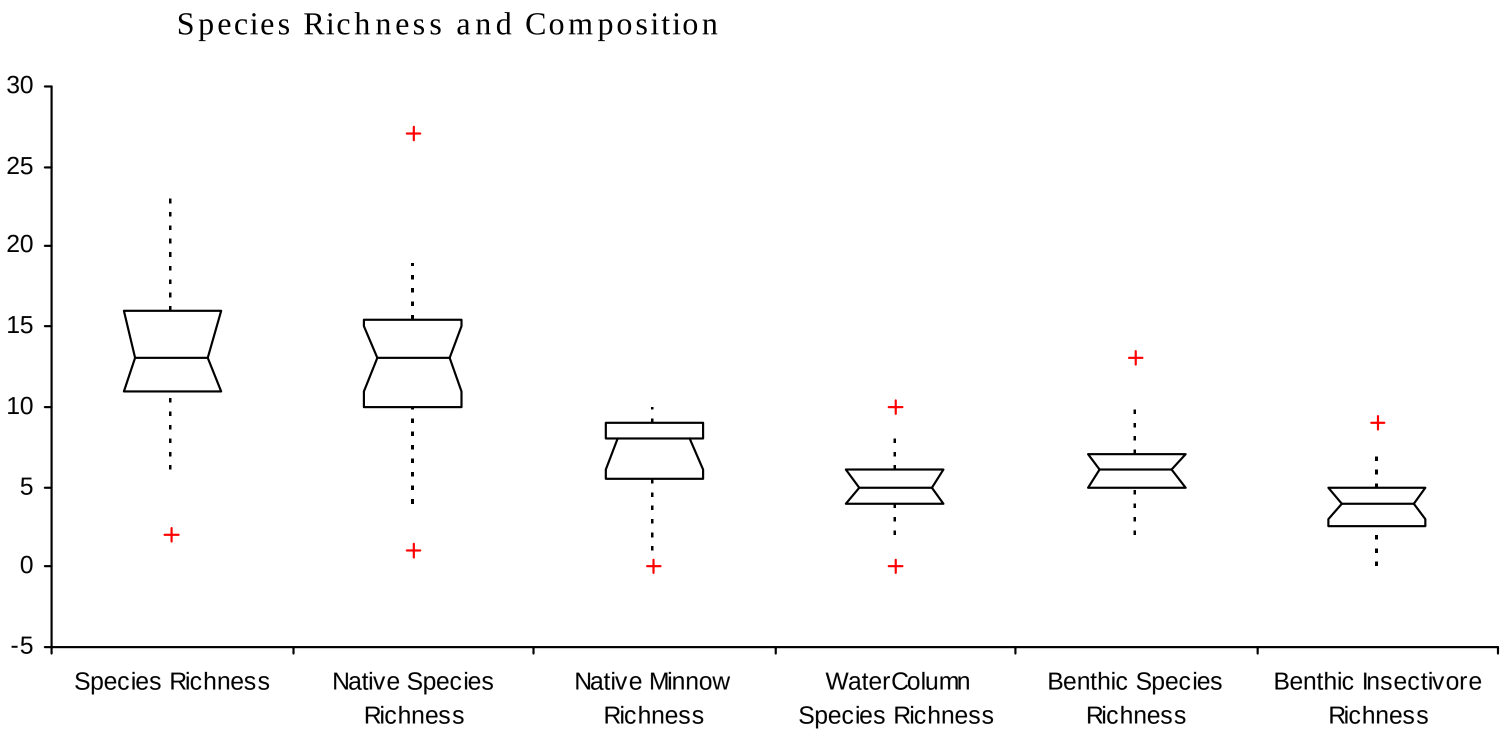
Metric: Number of individuals in sample
This metric is based on the concept that the number of individuals sampled per unit length or area of stream decreases as stream degradation increases. An alternative to be tested is biomass of fish per unit area of stream.

Metric: Proportion of individuals as hybrids
This metric evaluates the habitat degradation as it influences reproduction of stream fishes. Generally, as stream degradation increases, reproductive isolation breaks down and hybridization increases. Hybridization can be difficult to determine and does occur among minnows in streams that are not degraded. Alternatives often selected are proportion of individuals as simple lithophils or number of simple lithophilic species, which were selected also for the Big Sioux River system. (Core Metric 10 - % Simple Lithophil Biomass)

Metric: Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies
This metric is sensitive to the factors that cause poor health to a large proportion of individuals. A large proportion of individuals found in poor health are usually an indication of sub-acute effects of chemical pollution (Plafkin et al. 1989). This metric is usually retained in its original form. No alternatives are proposed for testing.

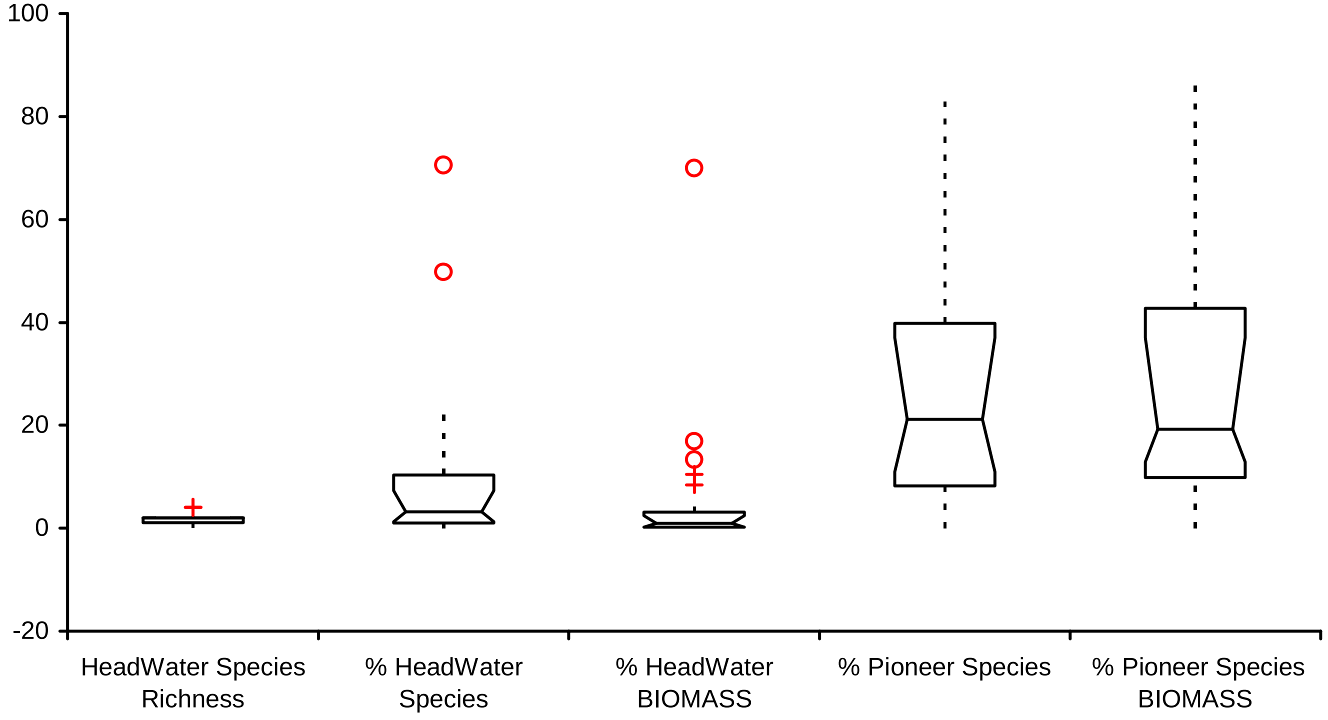
Appendix H.
Box Plots of Fish Metrics

Box Plots of Fish Metrics



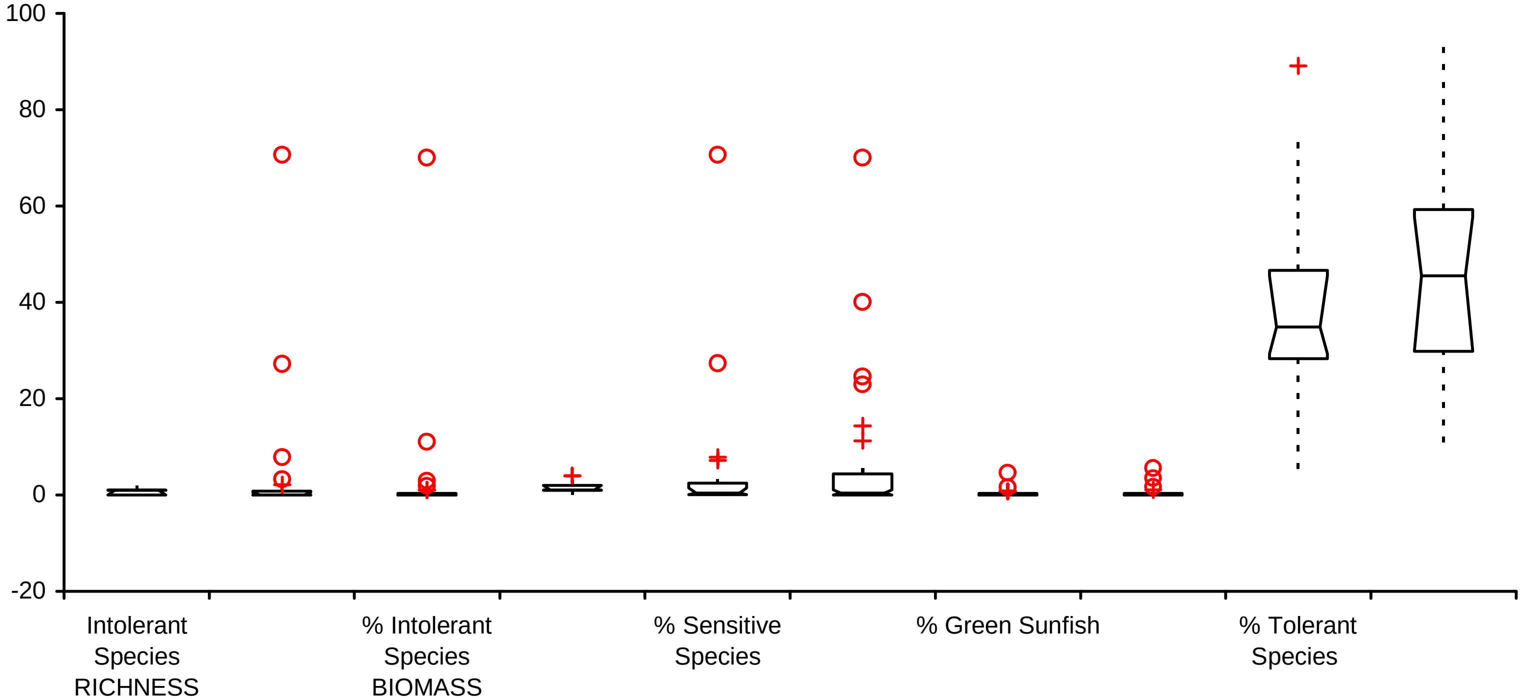
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
Species Richness	31	.3393	13.129	4.4553	0.8002	11.495	to 14.763	13.000	5.000	11.000	to 16.000
Native Species Richness	31	.4014	12.645	5.0764	0.9117	10.783	to 14.507	13.000	5.500	11.000	to 15.000
Native Minnow Richness	31	.3960	6.742	2.6704	0.4796	5.762	to 7.721	8.000	3.500	6.000	to 8.000
WaterColumn Species Richness	31	.3846	4.903	1.8860	0.3387	4.211	to 5.595	5.000	2.000	4.000	to 6.000
Benthic Species Richness	31	.4213	6.065	2.5552	0.4589	5.127	to 7.002	6.000	2.000	5.000	to 7.000
Benthic Insectivore Richness	31	.5037	3.935	1.9822	0.3560	3.208	to 4.663	4.000	2.500	3.000	to 5.000

Headwater/Pioneering Attributes



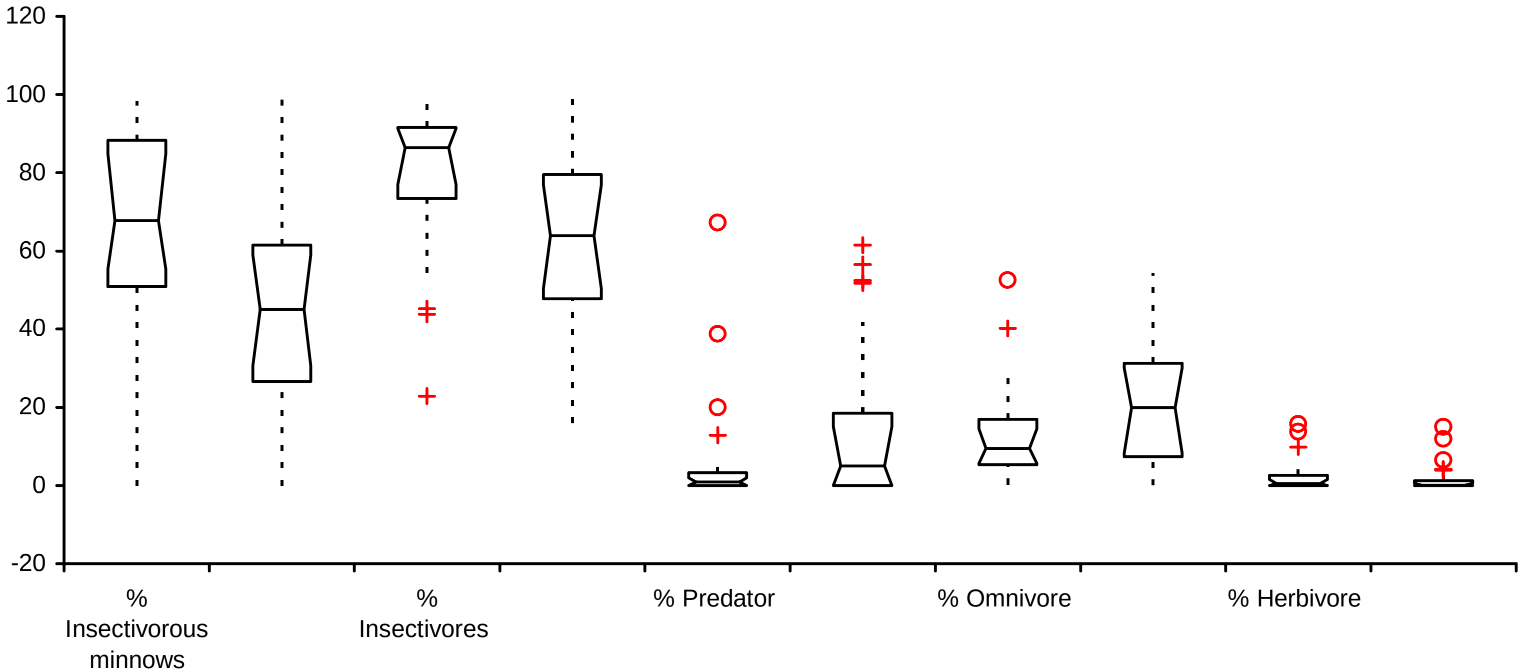
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
HeadWater Species Richness	31	.5298	1.871	0.9914	0.1781	1.507	to 2.235	2.000	1.000	2.000	to 2.000
% HeadWater Species	31	1.683	9.1498	15.40560	2.76693	3.499	to 14.801	3.1524	9.3689	1.289	to 7.237
% HeadWater BIOMASS	31	2.678	4.7807	12.80729	2.30026	0.083	to 9.478	0.8855	2.9624	0.169	to 2.426
% Pioneer Species	31	.8484	26.3071	22.32013	4.00881	18.120	to 34.494	21.1321	31.6217	10.985	to 37.040
% Pioneer Species BIOMASS	31	.8288	28.4811	23.60529	4.23963	19.823	to 37.140	19.2050	32.9665	12.839	to 37.054

Intolerant/Tolerant Attributes



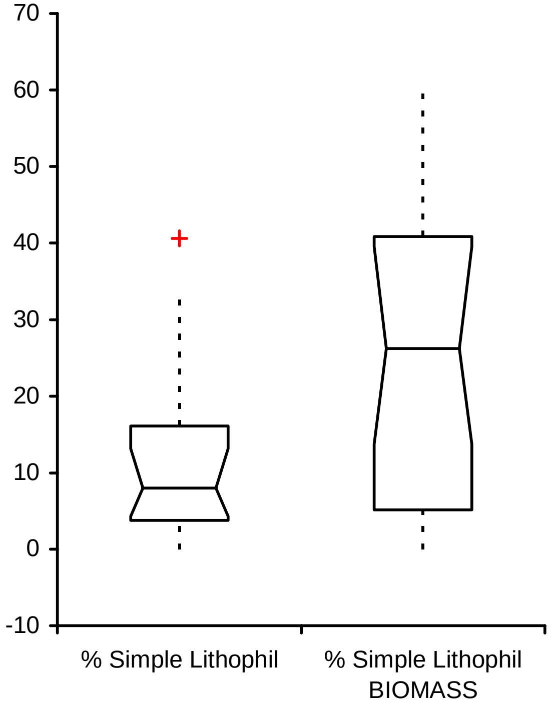
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
Intolerant Species RICHNESS	31	1.102	0.710	0.7829	0.1406	0.423	to 0.997	1.000	1.000	0.000	to 1.000
% Intolerant Species	31	3.543	3.7747	13.37392	2.40203	-1.131	to 8.680	0.0350	0.7640	0.000	to 0.510
% Intolerant Species BIOMASS	31	4.329	2.9139	12.61585	2.26587	-1.714	to 7.541	0.0286	0.3250	0.000	to 0.279
SensitiveSpecies Richness	31	.7920	1.452	1.1500	0.2066	1.030	to 1.873	1.000	1.000	1.000	to 2.000
% Sensitive Species	31	3.075	4.3246	13.29986	2.38873	-0.554	to 9.203	0.4036	2.3079	0.108	to 1.451
% Sensitive Species BIOMASS	31	2.248	6.6535	14.96005	2.68690	1.166	to 12.141	0.3589	4.3466	0.043	to 1.097
% Green Sunfish	31	2.389	0.3630	0.86755	0.15582	0.045	to 0.681	0.0000	0.2962	0.000	to 0.248
% Green Sunfish BIOMASS	31	2.456	0.4812	1.18184	0.21226	0.048	to 0.915	0.0000	0.3460	0.000	to 0.305
% Tolerant Species	31	.5003	39.3987	19.71289	3.54054	32.168	to 46.629	34.7938	18.3675	29.271	to 45.503
% Tolerant Species BIOMASS	31	.4909	46.2157	22.68881	4.07503	37.893	to 54.538	45.4589	29.4908	30.000	to 57.616

Trophic Guilds



	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
% Insectivorous minnows	31	.4495	64.6824	29.08119	5.22314	54.0154	to 75.3495	67.7013	37.4158	55.2632	to 84.7694
% Insectivorous minnows BIOMASS	31	.6201	43.9307	27.24271	4.89293	33.9380	to 53.9234	44.9670	34.8576	30.6152	to 58.8988
% Insectivores	31	.2287	79.4937	18.18622	3.26634	72.8229	to 86.1644	86.3636	18.2484	76.9737	to 91.3208
% Insectivores BIOMASS	31	.3407	62.8840	21.42702	3.84841	55.0245	to 70.7435	63.8256	31.8871	50.4012	to 76.9099
% Predator	31	2.4525	5.6468	13.84903	2.48736	0.5669	to 10.7266	0.9211	3.3104	0.0000	to 1.9601
% Predator BIOMASS	31	1.3808	14.3841	19.86228	3.56737	7.0986	to 21.6697	5.0146	18.5446	0.0000	to 15.0821
% Omnivore	31	.9402	12.6094	11.85546	2.12930	8.2608	to 16.9580	9.5361	11.6769	5.7226	to 14.5161
% Omnivore BIOMASS	31	.8041	21.0472	16.92498	3.03982	14.8391	to 27.2554	19.9130	23.9906	8.2884	to 30.1012
% Herbivore	31	1.7626	2.2502	3.96642	0.71239	0.7953	to 3.7051	0.5222	2.6059	0.0000	to 1.6129
% Herbivore BIOMASS	31	2.1000	1.6846	3.54091	0.63597	0.3858	to 2.9835	0.1425	1.2556	0.0000	to 0.6065

Reproduction



	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
% Simple Lithophil	31	.9518	10.5989	10.08888	1.81202	6.8982	to 14.2995	8.0044	12.3940	4.3178	to 13.1579
% Simple Lithophil BIOMASS	31	.7652	25.6925	19.66083	3.53119	18.4808	to 32.9041	26.2376	35.6782	13.7560	to 39.5220

Appendix I.
Score Sheets for Fishes by Site

Score Sheets for Fish Metrics - By Site

Site T01

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	12	60
Native Minnow Richness	Decrease	95th	10	6	60
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	3	86
% Pioneer Species	Increase	5th	0.78	63.82	36
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	94.36	7
% Insectivorous Minnows	Decrease	95th	95.63	52.76	55
% Omnivore Biomass	Increase	5th	0.24	9.66	91
% Simple Lithophil Biomass	Decrease	95th	55	0.64	1
			Final index value for this site:		**51**

Site T02

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	14	70
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	3	43
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	28.72	72
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	35.04	76
% Insectivorous Minnows	Decrease	95th	95.63	84.77	89
% Omnivore Biomass	Increase	5th	0.24	8.29	92
% Simple Lithophil Biomass	Decrease	95th	55	21.02	38
			Final index value for this site:		**65**

Site T03

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	15	75
Native Minnow Richness	Decrease	95th	10	9	90
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	37.04	63
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	62.68	44
% Insectivorous Minnows	Decrease	95th	95.63	48.86	51
% Omnivore Biomass	Increase	5th	0.24	52.36	48
% Simple Lithophil Biomass	Decrease	95th	55	53.04	96
			Final index value for this site:		**64**

Site T04

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	14	70
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	5	71
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	9.59	91
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	70.29	35
% Insectivorous Minnows	Decrease	95th	95.63	93.66	98
% Omnivore Biomass	Increase	5th	0.24	45.82	54
% Simple Lithophil Biomass	Decrease	95th	55	60.49	100
			Final index value for this site:		**71**

Site T05

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	14	70
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	21.13	79
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	55.26	53
% Insectivorous Minnows	Decrease	95th	95.63	83.02	87
% Omnivore Biomass	Increase	5th	0.24	1.79	98
% Simple Lithophil Biomass	Decrease	95th	55	13.76	25
			Final index value for this site:		**64**

Site T06

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	13	65
Native Minnow Richness	Decrease	95th	10	10	100
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	26.08	75
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	47.04	62
% Insectivorous Minnows	Decrease	95th	95.63	76.63	80
% Omnivore Biomass	Increase	5th	0.24	23.73	76
% Simple Lithophil Biomass	Decrease	95th	55	34.01	62
			Final index value for this site:		**69**

Site T07

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	16	80
Native Minnow Richness	Decrease	95th	10	10	100
Benthic Insectivore Richness	Decrease	95th	7	5	71
Headwater Species Richness	Decrease	95th	3.5	4	100
% Pioneer Species	Increase	5th	0.78	45.10	55
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	45.54	64
% Insectivorous Minnows	Decrease	95th	95.63	67.70	71
% Omnivore Biomass	Increase	5th	0.24	19.91	80
% Simple Lithophil Biomass	Decrease	95th	55	48.75	89
				Final index value for this site:	**77**

Site T08

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	17	85
Native Minnow Richness	Decrease	95th	10	9	90
Benthic Insectivore Richness	Decrease	95th	7	6	86
Headwater Species Richness	Decrease	95th	3.5	3	86
% Pioneer Species	Increase	5th	0.78	36.03	64
Sensitive Species Richness	Decrease	95th	3.5	3	86
% Tolerant Species Biomass	Increase	5th	14.85	61.13	46
% Insectivorous Minnows	Decrease	95th	95.63	59.85	63
% Omnivore Biomass	Increase	5th	0.24	31.99	68
% Simple Lithophil Biomass	Decrease	95th	55	44.57	81
				Final index value for this site:	**75**

Site T09

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	20	100
Native Minnow Richness	Decrease	95th	10	10	100
Benthic Insectivore Richness	Decrease	95th	7	6	86
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	12.80	88
Sensitive Species Richness	Decrease	95th	3.5	4	100
% Tolerant Species Biomass	Increase	5th	14.85	29.75	83
% Insectivorous Minnows	Decrease	95th	95.63	90.63	95
% Omnivore Biomass	Increase	5th	0.24	11.48	89
% Simple Lithophil Biomass	Decrease	95th	55	56.52	100
				Final index value for this site:	**90**

Site T10

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	2	10
Native Minnow Richness	Decrease	95th	10	0	0
Benthic Insectivore Richness	Decrease	95th	7	1	14
Headwater Species Richness	Decrease	95th	3.5	1	29
% Pioneer Species	Increase	5th	0.78	0.00	100
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	30.00	82
% Insectivorous Minnows	Decrease	95th	95.63	0.00	0
% Omnivore Biomass	Increase	5th	0.24	30.00	70
% Simple Lithophil Biomass	Decrease	95th	55	0.00	0
			Final index value for this site:		**33**

Site T11

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	11	55
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	3	43
Headwater Species Richness	Decrease	95th	3.5	3	86
% Pioneer Species	Increase	5th	0.78	38.89	62
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	60.34	47
% Insectivorous Minnows	Decrease	95th	95.63	66.01	69
% Omnivore Biomass	Increase	5th	0.24	26.12	74
% Simple Lithophil Biomass	Decrease	95th	55	47.38	86
			Final index value for this site:		**60**

Site T13

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	13	65
Native Minnow Richness	Decrease	95th	10	6	60
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	54.08	46
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	56.72	51
% Insectivorous Minnows	Decrease	95th	95.63	59.18	62
% Omnivore Biomass	Increase	5th	0.24	13.49	87
% Simple Lithophil Biomass	Decrease	95th	55	39.52	72
			Final index value for this site:		**59**

Site T14

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	13	65
Native Minnow Richness	Decrease	95th	10	9	90
Benthic Insectivore Richness	Decrease	95th	7	3	43
Headwater Species Richness	Decrease	95th	3.5	4	100
% Pioneer Species	Increase	5th	0.78	6.77	94
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	24.50	89
% Insectivorous Minnows	Decrease	95th	95.63	93.81	98
% Omnivore Biomass	Increase	5th	0.24	8.37	92
% Simple Lithophil Biomass	Decrease	95th	55	13.84	25
			Final index value for this site:		**72**

Site T15

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	6	30
Native Minnow Richness	Decrease	95th	10	3	30
Benthic Insectivore Richness	Decrease	95th	7	2	29
Headwater Species Richness	Decrease	95th	3.5	0	0
% Pioneer Species	Increase	5th	0.78	0.31	100
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	16.91	98
% Insectivorous Minnows	Decrease	95th	95.63	98.45	100
% Omnivore Biomass	Increase	5th	0.24	4.34	96
% Simple Lithophil Biomass	Decrease	95th	55	4.34	8
			Final index value for this site:		**49**

Site T16

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	10	50
Native Minnow Richness	Decrease	95th	10	1	10
Benthic Insectivore Richness	Decrease	95th	7	2	29
Headwater Species Richness	Decrease	95th	3.5	1	29
% Pioneer Species	Increase	5th	0.78	82.90	17
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	89.99	12
% Insectivorous Minnows	Decrease	95th	95.63	0.00	0
% Omnivore Biomass	Increase	5th	0.24	3.40	97
% Simple Lithophil Biomass	Decrease	95th	55	0.02	0
			Final index value for this site:		**24**

Site T17

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	8	40
Native Minnow Richness	Decrease	95th	10	1	10
Benthic Insectivore Richness	Decrease	95th	7	0	0
Headwater Species Richness	Decrease	95th	3.5	0	0
% Pioneer Species	Increase	5th	0.78	3.28	97
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	29.78	82
% Insectivorous Minnows	Decrease	95th	95.63	3.28	3
% Omnivore Biomass	Increase	5th	0.24	27.41	73
% Simple Lithophil Biomass	Decrease	95th	55	27.41	50
			Final index value for this site:		**36**

Site T18

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	11	55
Native Minnow Richness	Decrease	95th	10	5	50
Benthic Insectivore Richness	Decrease	95th	7	5	71
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	40.71	60
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	45.46	64
% Insectivorous Minnows	Decrease	95th	95.63	47.14	49
% Omnivore Biomass	Increase	5th	0.24	0.38	100
% Simple Lithophil Biomass	Decrease	95th	55	0.00	0
			Final index value for this site:		**56**

Site T19

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	8	40
Native Minnow Richness	Decrease	95th	10	5	50
Benthic Insectivore Richness	Decrease	95th	7	2	29
Headwater Species Richness	Decrease	95th	3.5	1	29
% Pioneer Species	Increase	5th	0.78	1.24	100
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	16.94	98
% Insectivorous Minnows	Decrease	95th	95.63	91.30	95
% Omnivore Biomass	Increase	5th	0.24	0.10	100
% Simple Lithophil Biomass	Decrease	95th	55	0.00	0
			Final index value for this site:		**54**

Site T20

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	9	45
Native Minnow Richness	Decrease	95th	10	6	60
Benthic Insectivore Richness	Decrease	95th	7	3	43
Headwater Species Richness	Decrease	95th	3.5	1	29
% Pioneer Species	Increase	5th	0.78	10.98	90
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	35.40	76
% Insectivorous Minnows	Decrease	95th	95.63	83.71	88
% Omnivore Biomass	Increase	5th	0.24	0.07	100
% Simple Lithophil Biomass	Decrease	95th	55	21.50	39
			Final index value for this site:		**60**

Site T21

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	16	80
Native Minnow Richness	Decrease	95th	10	7	70
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	1	29
% Pioneer Species	Increase	5th	0.78	6.62	94
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	41.01	69
% Insectivorous Minnows	Decrease	95th	95.63	89.93	94
% Omnivore Biomass	Increase	5th	0.24	26.34	74
% Simple Lithophil Biomass	Decrease	95th	55	53.47	97
			Final index value for this site:		**69**

Site T22

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	13	65
Native Minnow Richness	Decrease	95th	10	6	60
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	1	29
% Pioneer Species	Increase	5th	0.78	43.42	57
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	89.20	13
% Insectivorous Minnows	Decrease	95th	95.63	55.26	58
% Omnivore Biomass	Increase	5th	0.24	16.13	84
% Simple Lithophil Biomass	Decrease	95th	55	20.31	37
			Final index value for this site:		**52**

Site T23

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	20	100
Native Minnow Richness	Decrease	95th	10	9	90
Benthic Insectivore Richness	Decrease	95th	7	6	86
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	4.69	96
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	39.12	71
% Insectivorous Minnows	Decrease	95th	95.63	93.28	98
% Omnivore Biomass	Increase	5th	0.24	7.88	92
% Simple Lithophil Biomass	Decrease	95th	55	26.24	48
			Final index value for this site:		**80**

Site T25

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	11	55
Native Minnow Richness	Decrease	95th	10	7	70
Benthic Insectivore Richness	Decrease	95th	7	2	29
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	66.04	34
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	79.41	24
% Insectivorous Minnows	Decrease	95th	95.63	43.09	45
% Omnivore Biomass	Increase	5th	0.24	51.11	49
% Simple Lithophil Biomass	Decrease	95th	55	22.20	40
			Final index value for this site:		**40**

Site T26

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	11	55
Native Minnow Richness	Decrease	95th	10	5	50
Benthic Insectivore Richness	Decrease	95th	7	2	29
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	20.97	80
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	37.18	74
% Insectivorous Minnows	Decrease	95th	95.63	27.42	29
% Omnivore Biomass	Increase	5th	0.24	30.10	70
% Simple Lithophil Biomass	Decrease	95th	55	28.75	52
				Final index value for this site:	**52**

Site T27

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	16	80
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	5	71
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	27.31	73
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	51.53	57
% Insectivorous Minnows	Decrease	95th	95.63	72.69	76
% Omnivore Biomass	Increase	5th	0.24	54.15	46
% Simple Lithophil Biomass	Decrease	95th	55	41.50	75
				Final index value for this site:	**64**

Site T28

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	16	80
Native Minnow Richness	Decrease	95th	10	9	90
Benthic Insectivore Richness	Decrease	95th	7	4	57
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	13.93	87
Sensitive Species Richness	Decrease	95th	3.5	3	86
% Tolerant Species Biomass	Increase	5th	14.85	58.16	49
% Insectivorous Minnows	Decrease	95th	95.63	82.24	86
% Omnivore Biomass	Increase	5th	0.24	31.68	68
% Simple Lithophil Biomass	Decrease	95th	55	40.15	73
				Final index value for this site:	**73**

Site T29

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	18	90
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	7	100
Headwater Species Richness	Decrease	95th	3.5	3	86
% Pioneer Species	Increase	5th	0.78	24.67	76
Sensitive Species Richness	Decrease	95th	3.5	3	86
% Tolerant Species Biomass	Increase	5th	14.85	29.08	83
% Insectivorous Minnows	Decrease	95th	95.63	67.41	70
% Omnivore Biomass	Increase	5th	0.24	32.77	67
% Simple Lithophil Biomass	Decrease	95th	55	36.33	66
				Final index value for this site:	**80**

Site T30

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	17	85
Native Minnow Richness	Decrease	95th	10	8	80
Benthic Insectivore Richness	Decrease	95th	7	7	100
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	11.45	89
Sensitive Species Richness	Decrease	95th	3.5	2	57
% Tolerant Species Biomass	Increase	5th	14.85	21.55	92
% Insectivorous Minnows	Decrease	95th	95.63	86.53	90
% Omnivore Biomass	Increase	5th	0.24	45.16	55
% Simple Lithophil Biomass	Decrease	95th	55	32.20	59
				Final index value for this site:	**76**

Site T31

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	13	65
Native Minnow Richness	Decrease	95th	10	6	60
Benthic Insectivore Richness	Decrease	95th	7	5	71
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	60.73	40
Sensitive Species Richness	Decrease	95th	3.5	1	29
% Tolerant Species Biomass	Increase	5th	14.85	12.80	100
% Insectivorous Minnows	Decrease	95th	95.63	23.64	25
% Omnivore Biomass	Increase	5th	0.24	6.79	93
% Simple Lithophil Biomass	Decrease	95th	55	1.74	3
				Final index value for this site:	**54**

Site T32

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	7	35
Native Minnow Richness	Decrease	95th	10	5	50
Benthic Insectivore Richness	Decrease	95th	7	1	14
Headwater Species Richness	Decrease	95th	3.5	0	0
% Pioneer Species	Increase	5th	0.78	5.13	96
Sensitive Species Richness	Decrease	95th	3.5	0	0
% Tolerant Species Biomass	Increase	5th	14.85	57.62	50
% Insectivorous Minnows	Decrease	95th	95.63	97.44	100
% Omnivore Biomass	Increase	5th	0.24	0.66	100
% Simple Lithophil Biomass	Decrease	95th	55	5.96	11
				Final index value for this site:	**46**

Site T33

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Species Richness	Decrease	95th	20	23	100
Native Minnow Richness	Decrease	95th	10	9	90
Benthic Insectivore Richness	Decrease	95th	7	9	100
Headwater Species Richness	Decrease	95th	3.5	2	57
% Pioneer Species	Increase	5th	0.78	11.08	90
Sensitive Species Richness	Decrease	95th	3.5	4	100
% Tolerant Species Biomass	Increase	5th	14.85	10.89	100
% Insectivorous Minnows	Decrease	95th	95.63	65.46	68
% Omnivore Biomass	Increase	5th	0.24	30.97	69
% Simple Lithophil Biomass	Decrease	95th	55	0.81	1
				Final index value for this site:	**78**

Appendix J.
EcoAnalyst, Inc Contract and Laboratory Procedures

Contract No. 1, EcoAnalysts, Inc. and East Dakota Water Development District

Contract for Services

This agreement, made the 20th day of November, 2000 is between EcoAnalysts, Inc. and East Dakota Water Development District, referred to in this document as the District.

A. **Scope of Services**: EcoAnalysts, Inc. agrees to provide macroinvertebrate identifications and metric calculations for samples collected from the Big Sioux River and provided by the District, to a level of taxonomic resolution equivalent to or below the taxonomic level (generally species) previously identified by the South Dakota Department of Environment and Natural Resources (SDDENR). Results will include the following:

1. The sample analysis will include a 300 count per sample for 5 kick seine samples collected in 1999 and for 18 rock basket samples collected in 2000. Each of these 23 samples is a composite of 3 kick seines or 3 to 5 baskets per site.

2. Standard laboratory protocols for the SDDENR will be followed in the analysis

3. Standard QA/QC protocols for the SDDENR will be followed in the analysis as described in Exhibit A.

4. Hard and electronic copies (Electronic Data Deliverables-EDD) will be required for the data.

5. The functional feeding group assignments, i.e. gatherer, shredder, piercer etc., will be included for each genus/species in the EDD.

6. The biotic index value (tolerance values) will be included for each genus species in the EDD.

7. Calculation of the 42 metrics on the in Attachment A, page 6 will be completed for the 23 samples.

8. The voucher collection described in the standard laboratory protocols (Exhibit A) will include a set of permanent slides of the head capsules and/or whole mounts of the identified chironomidae genus/species.

9. A summary of the methods, equipment and keys used to identify macroinvertebrate samples will be provided.

Data will be provided in both hard copy and EDD. All samples submitted will have a 90-day turn around time upon receipt by Ecoanalysts, Inc.. A five-percent reduction in per sample price will be deducted for every week delay in receipt of deliverables.

B. **Responsibilities of the District:** The District agrees to provide general direction and necessary District coordination and contracts relating to the Scope of Services outlined in paragraph A. The District will provide macroinvertebrate samples collected during the 1999 and 2000 Central Big Sioux River Watershed Assessment in one group.

C. **Compensation:** The District agrees to pay EcoAnalysts, Inc. $170.^{00}$/sample for professional services rendered. This covers three items: $50.^{00}$/sample for sorting, $70.^{00}$/sample for identification, and $50.^{00}$/sample for chironomid identification. The total contract will not exceed $3910.^{00}$. EcoAnalysts, Inc. will send a monthly invoice to the District for services completed by the end of each month of the contract with a description of sample items completed. The District will pay EcoAnalysts, Inc. within 30 days of receipt of each monthly invoice.

D. **Other Conditions:** The District will be reimbursed for these costs through Environmental Protection Agency 319 funds for the Central Big Sioux River Watershed assessment.

E. **Federal Aid Requirements:** EcoAnalysts, Inc. agrees with the following federal aid requirements:

1. To comply with Executive order 11246, concerning Equal Employment Opportunity.
2. Complete, sign and return the MBE/WBE forms (attached).

F. **Amendments:** This contract may be amended with written approval of both parties.

G. **Terms:** This contract shall run from November 20, 2000 to March 1, 2001.

H. **Additional Work:** For additional services other than those listed in Section A, a separate contract will be negotiated between the District and EcoAnalysts, Inc. on a per sample basis.

I. **Hold Harmless:** The EcoAnalysts, Inc. agrees to hold harmless and indemnify the East Dakota Water Development District, its officers, agents and employees, from and against any and all actions, suits, damages, liability or other proceedings which may arise as a result of performing services hereunder. This section does not require the EcoAnalysts, Inc. to be responsible for or defend against claims or damages arising solely from acts or omissions of the East Dakota Water Development District, its officers or employees.

J. **Insurance Provision:** Does the State agency require an insurance provision?

YES __X__ NO _____

If YES, does the EcoAnalysts, Inc. agree, at its sole cost and expense, to maintain adequate general liability, worker's compensation, professional liability and automobile liability insurance during the period of this Agreement? YES __X__ NO ______

K. **Termination:** The District can terminate this agreement if the District determines that adequate progress is not being made. The District shall give a two week written notice of any such termination, and shall pay for all services performed and expenses incurred up through the effective date of such termination.

All parties find this contract in order and agree to comply with the responsibilities and conditions outlined.

_______________________________________ ________________

Gary T. Lester, President Date
EcoAnalysts, Inc.

____

EcoAnalysts, Inc. - Tax ID #

_______________________________________ ________________

Jay Gilbertson, Manager Date

East Dakota Water Development District

I certify that I am a …
(sign and check all that apply)

______ Minority Business Enterprise

______ Woman Business Enterprise

FOR AGENCY USE

-State Agency Coding (MSA Center)____

-State Agency MSA company from which contract is to be paid

____

-Object/subject MSA Account to which voucher(s) will be coded

____

EXHIBIT A

The following metrics will need to be calculated for the kick seine samples collected in 1999 and the rock basket samples collected in 2000.

Category	Number	**Metric**
Richness Measures	1	Total No. Taxa
	2	No. of EPT Taxa
	3	No. of Ephemeroptera Taxa
	4	No. of Trichoptera Taxa
	5	No. of Plecoptera Taxa
	6	No. of Diptera Taxa
	7	No. of Chironomidae Taxa
Composition Measures	8	Ratio EPT/Chironomidae Abundance
	9	%EPT
	10	%Ephemeroptera
	11	%Plecoptera
	12	%Trichoptera
	13	%Chironomidae
	14	% Tribe Tanytarsini
	15	% Diptera
	16	% Other Diptera and Noninsects
	17	% Oligochaeta
	18	Pinkham-Pearson
	19	Jaccard Similarity Index
	20	Shannon-Weiner Index
	21	Index of Community Integrity
	22	% Similarity
Tolerance/Intolerance Measures	23	No. of Intolerant Taxa
	24	No. of Sediment Intolerant Taxa
	25	% Tolerant Organisms
	26	% Sediment Tolerant Organisms
	27	% Dominant Taxon
	28	Hilsenhoff Biotic Index
	29	Biotic Index
	30	Biotic Condition Index
	31	Ratio Hydropsychidae/Trichoptera
	32	Total Abundance (Density)
Feeding Measures	33	No. of Predator Taxa
	34	% Omnivores and Scavengers
	35	% Ind. Gatherers and filterers
	36	% Gatherers
	37	% Filterers
	38	% Grazers and Scrapers
	39	Ratio Scrapers/Filterers
	40	Ratio Scrapers/(Scrapers+Filterers)
	41	% Strict Predators
	42	% Shredders

Laboratory Procedures for Macroinvertebrate Identification

1. Prior to processing any samples in a lot (i.e., samples within a collection date, specific watershed, or project), complete the sample log-in sheet to verify that all samples have arrived at the laboratory, and are in proper condition for processing.
2. Thoroughly rinse sample in a 500 μm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for given sample should be combined at this time. Gently mix the sample by hand while rinsing to make homogeneous.
3. Floating and picking the sample can be completed if there is an inordinate amount of organic debris within the sample. This can be completed by various methods as long as visible degradation on the organisms within the sample does not occur. There are a variety of flotation methods available and any one can be used, i.e. sugar or epsom salts. Other methodologies may be employed so long as the individual organisms within the samples are not significantly damaged which may hinder the identification process.
4. After washing, spread the sample evenly across a pan marked with grids approximately 6 cm x 6 cm. On the laboratory bench sheet, note the presence of large or obviously abundant organisms; do not remove them from the pan. However, Vinson and Hawkins (1996) present an argument for including these large organisms in the count, because of the high probability that these organisms will be excluded from the targeted grids.
5. Use a random numbers table to select 4 numbers corresponding to squares (grids) within the gridded pan. Remove all material (organisms and debris) from the four gird squares, and place the material into a shallow white pan and add a small amount of water to facilitate sorting. If there appear (through a cursory count or observation) to be 100 organisms ± 20% (cumulative of 4 grids), then subsampling is complete.

    Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organisms is considered to be in the gird containing most of its body.

    If the density of organisms is high enough that many more than 100/200/300 organisms are contained in the 4 grids, transfer the contents of the 4 grids to a second gridded pan. Randomly select grids for this second level of sorting as was done for the first, sorting grids one at a time until 100/200/300 organisms ± 20% are found. If picking through the entire next grid is likely to result in a subsample of greater than 120/240/360 organisms, then that grid may be subsampled in the sample manner as before to decrease the likelihood of exceeding 120/240/360 organisms. That is, spread the contents of the last grid into another gridded pan. Pick grids one at a time until the desired number is reached. The total number of grids for each subsorting level should be noted on the laboratory bench sheet.

6. Save the sorted debris residue in a separate container. Add a label that includes the words “sorted residue” in addition to all prior sample label information and preserve in 95% ethanol. Save the remaining unsorted sample debris residue in a separate container labeled “sample

residue”; this container should include the original sample label. Length of storage and archival is determined by the laboratory or benthic section supervisor.

7. Place the sorted 100/200/300-organism (±20%) subsample into glass vials, and preserve in 70% ethanol. Label the vials inside with the sample identifier or lot number, date, stream name, sampling location and taxonomic group. If more than one vial is needed, each should be labeled separately and numbered (e.g., 1 of 2, 2 of 2). For convenience in reading the labels inside the vials, insert the labels left-edge first. If identification is to occur immediately after sorting, a petri dish or watch glass can be used instead of vials.
8. Midges (Chironomidae) should be mounted on slides in an appropriate medium (e.g., Euperal, CMC-10); slides should be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled.
9. Fill out header information on Laboratory Bench Sheet as in field sheets. Also check subsample target number. Complete back of sheet for subsampling/sorting information. Note number of grids picked, time expenditure, and number of organisms. If on the back of the laboratory Bench Sheet. Calculate sorting efficiency to determine whether sorting effort passes or fails.
10. Record date of sorting and slide monitoring, if applicable, on Log-In Sheet as documentation of progress and status of sample lot.

QUALITY CONTROL (QC) FOR SORTING

1. Ten Percent of the sorted samples in each lot should be examined by laboratory QC personnel or a qualified co-worker. (A lot is defined as a special study, basin study, entire index period, or individual sorter.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials. If the QC worker finds less than 10 organisms (or 10% in larger subsamples) remaining in the grids or sorting tray, the sample passes; if more than 10 (or 10%) are found, the sample fails. If the first 10% of the sample lot fails, a second 10% of the sample lot will be checked by the QC worker. Sorter in-training will have their samples 100% checked until the trainer decides that training is complete.
2. After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

IDENTIFICATION OF MACROINVERTEBRATES

Taxonomy can be at any level, but should be consistent among samples. In the original RBPs, two levels of identification were suggested – family (RBP II) and genus/species (RBP III) level (Plafkin et al. 1989). Genus/species will provide more accurate information on ecological/environmental relationships and sensitivity to impairment. Family level will provide a higher degree of precision among samples and taxonomists, requires less expertise to perform, and accelerates assessment results. In either case, only those taxonomic keys that have been peer reviewed and are published in some way to be available to other taxonomists should be used. Unnamed species (i.e., species A, B, 1 or 2) may be ecologically informative, but will contribute to variability and inconsistency when a statewide database is being developed.

1. Most organisms are identified to the lowest practical level (generally genus or species) by a qualified taxonomist using a dissecting microscope. Midges (Diptera: Chironomidae) are mounted on slides in an appropriate medium and identified using a compound microscope.

Each taxon found in a sample is recorded and enumerated in a laboratory bench notebook and then transcribed to the laboratory bench sheet for subsequent reports. Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

2. Labels with specific taxa names (and taxonomist's initials) are added to the vials of specimens by the taxonomist. Individual specimens may be extracted from the sample to be included in a reference collection or to be verified by a 2nd taxonomist. Slides are initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.
3. Record the identity and number of organisms on the Laboratory Bench Sheet. Either a tally counter or "slash" marks on the bench sheet can be done to keep track of the cumulative count. Also, record the life stage of the organisms, taxonomist's initials and taxonomic certainty rating (TCR) as a measure of confidence.
4. Complete the back of the bench sheet to explain certain TCR ratings or condition of organisms. Other comments can be included to provide additional insights for data interpretation. If QC was performed, record on back of sheet.
5. For archiving samples, specimen vials, grouped by station and date, are placed in jars with a small amount of denatured 70% ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vials takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (denatured 70% ethanol).

IDENTIFICATION QA/QC PROCEDURES OF MACROINVERTEBRATES

1. A voucher collection of all samples and subsamples should be maintained. These specimens should be properly labeled, preserved, and stored in the laboratory for future reference. A taxonomist (the reviewer) not responsible for the original identifications should spot check samples corresponding to the identifications on the bench sheet.
2. The reference collection of each identified taxon should also be maintained and verified by a second taxonomist. The word "val." and the 1st initial and last name of the person validating the identification should be added to the vial label. Specimens sent out for taxonomic validations should be recorded in a "Taxonomy Validation Notebook" showing the label information and the date sent out. Upon return of the specimens, the date received and the finding should also be recorded in the notebook along with the name of the person who performed the validation.
3. Information on samples completed (through the identification process) will be recorded in the "sample log" notebook to track the progress of each sample within the sample lot. Tracking of each sample will be updated as each step is completed (i.e., subsampling and sorting, mounting of midges and worms, taxonomy).

Appendix K.
Natural Resource Solutions Contract and Laboratory Procedures

Contract No. 1, Natural Resource Solutions, Inc. and East Dakota Water Development District

Contract for Services

This agreement, made the 19th day of October 2001 is between Natural Resource Solutions and East Dakota Water Development District, referred to in this document as the District.

B. **Scope of Services**: Natural Resource Solutions agrees to provide macroinvertebrate identifications and metric calculations for samples collected from sites in the Central Big Sioux River Watershed Assessment by the District. The level of taxonomic resolution will be equivalent to or below the taxonomic level (generally species) previously identified by the South Dakota Department of Environment and Natural Resources (SDDENR). Results will include the following:

10. Macroinvertebrate will be identified and enumerated for 35 rock basket samples collected at 23 sites in 2001. Seventeen of these samples are composite samples of 3 to 4 rock baskets per site for 17 sites. Eighteen of these samples comprise 3 individually preserved rock baskets per site for 6 sites.

11. Calculation of the 39 metrics in Table 1 will be completed for the 35 samples. These metrics will be subject to review for appropriateness for assessment and monitoring of the Big Sioux River. The Project Leader at EDWDD and Natural Resource Solutions must agree upon any changes.

12. A report will be prepared that includes a description of the major taxonomic groups and water quality conditions they are usually associated with.

13. Hard and electronic copies (Electronic Data Deliverables-EDD) will be required for the data.

14. The functional feeding group assignments, i.e. gatherer, shredder, piercer etc., will be included for each genus/species in the EDD.

15. The biotic index value (tolerance values) will be included for each genus species in the EDD.

16. Standard laboratory protocols for the SDDENR will be followed in the analysis (Appendix A).

17. Standard QA/QC protocols be followed in the future if deemed necessary (Appendix A).

18. The voucher collection described in the standard laboratory protocols (Appendix A) will include a set of permanent slides of the head capsules and/or whole mounts of the identified chironomidae genus/species.

19. A summary of the methods, equipment and keys used to identify macroinvertebrate samples will be provided.

Results for all samples submitted to Natural Resource Solutions by October 31, 2001 will be provided to the District by March 15, 2002. A five-percent reduction in per sample price will be deducted for every week delay in receipt of results.

A summary of cost is presented in Table 2.

L. **Responsibilities of the District:** The District agrees to provide general direction and necessary District coordination and contracts relating to the Scope of Services outlined in paragraph A. The District will provide macroinvertebrate samples collected during the 2001 Central Big Sioux River Watershed Assessment in one group.

M. **Compensation:** The District agrees to pay Natural Resource Solutions $\underline{\$185.^{00}\text{/sample}}$ for professional services rendered. This covers four items: $\$35.^{00}$/sample for sorting, $\$45.^{00}$/sample for identification, $\$75.^{00}$/sample for chironomid and oligochaete identification, and $\$30.^{00}$/sample data compilation and metric calculation. In addition, a report will be prepared that provides a synopsis of results, and a reference collection of additional and new macroinvertebrates that are not currently available in the District's macroinvertebrate reference collection will also be provided. The total contract will not exceed $\underline{\$6675.^{00}}$. Natural Resource Solutions will send a monthly invoice to the District for services completed by the end of each month of the contract with a description of sample items completed. The District will pay Natural Resource Solutions within 30 days of receipt of each monthly invoice.

N. **Other Conditions:** The District will be reimbursed for these costs through Environmental Protection Agency 319 funds for the Central Big Sioux River Watershed assessment.

O. **Federal Aid Requirements:** Natural Resource Solutions agrees with the following federal aid requirements:

3. To comply with Executive order 11246, concerning Equal Employment Opportunity.
4. Complete, sign and return the MBE/WBE forms (attached).

P. **Amendments:** This contract may be amended with written approval of both parties.

Q. **Terms:** This contract shall run from October 31, 2001 to March 15, 2002.

R. **Additional Work:** For additional services other than those listed in Section A, a separate contract will be negotiated between the District and Natural Resource Solutions on a per sample basis.

S. **Hold Harmless:** The Natural Resource Solutions agrees to hold harmless and indemnify the East Dakota Water Development District, its officers, agents and employees, from and against any and all actions, suits, damages, liability or other proceedings which may arise as a result of performing services hereunder. This section does not require the Natural Resource Solutions to be responsible for or defend against claims or damages arising solely from acts or omissions of the East Dakota Water Development District, its officers or employees.

T. **Insurance Provision:** Does the State agency require an insurance provision?
YES __X__ NO _____

If YES, does the Natural Resource Solutions agree, at its sole cost and expense, to maintain adequate general liability, worker's compensation, professional liability and automobile liability insurance during the period of this Agreement? YES __X__ NO ______

U. **Termination:** The District can terminate this agreement if the District determines that adequate progress is not being made. The District shall give a two week written notice of any such termination, and shall pay for all services performed and expenses incurred up through the effective date of such termination.

All parties find this contract in order and agree to comply with the responsibilities and conditions outlined.

______________________________ ______________
Rebecca L. Spawn-Stroup, Owner Date
Natural Resource Solutions

____
Natural Resource Solutions - Tax ID #

______________________________ ______________
Jay Gilbertson, Manager Date

I certify that I am a …
(sign and check all that apply)

___X___Minority Business Enterprise

___X_ _Woman Business Enterprise

FOR AGENCY USE

-State Agency Coding (MSA Center)____

-State Agency MSA company from which contract is to be paid

____

-Object/subject MSA Account to which voucher(s) will be coded

____

Table 1. The following metrics will be calculated for the rock basket samples collected in 2001.		
Category	**Number**	**Metric**
Abundance Measures	1	Corrected abundance
	2	EPT abundance
Richness Measures	3	Total number of taxa
	4	Number of EPT taxa
	5	Number of Ephemeroptera taxa
	6	Number of Trichoptera taxa
	7	Number of Plecoptera taxa
	8	Number of Diptera taxa
	9	Number of Chironomidae taxa
Composition Measures	10	Ratio EPT/Chironomidae Abundance
	11	%EPT
	12	%Ephemeroptera
	13	%Plecoptera
	14	%Trichoptera
	15	% Coleoptera
	16	% Diptera
	17	% Oligochaeta
	18	% Baetidae
	19	% Hydropsychidae
	20	% Chironomidae
	21	% Simuliidae
	22	Shannon-Wiener Index
Tolerance/Intolerance Measures	23	No. of Intolerant Taxa
	24	% Tolerant Organisms
	25	% Sediment Tolerant Organisms
	26	Hilsenhoff Biotic Index
	27	% Dominant Taxon
	28	% Hydropsychidae to Trichoptera
	29	% Baetidae to Ephemeroptera
Feeding Measures	30	% individuals as gatherers and filterers
	31	% gatherers
	32	% filterers
	33	% shredders
	34	% grazers and scrapers
	35	Ratio scrapers/(scrapers+filterers)
	36	Number of gatherer taxa
	37	Number of filterer taxa
	38	Number of shredder taxa
	39	Number of grazer/scraper taxa

Table 2. Summary of cost for contract work.

Activity	Quantity	Cost	Total
Sample Processing	35 samples	$185.00/sample	$6475.00
Report Preparation	1	$150.00	$150.00
General Reference Collection[1]	1	$25.00	$25.00
Slide-mounted Reference Collection[1]	1	$25.00	$25.00
		Grand Total	**$6675.00**

[1]Only macroinvertebrates that would be new additions to the District's collection.

APPENDIX A.
MACROINVERTEBRATE ENUMERATION AND IDENTIFICATION

Laboratory Procedures for Macroinvertebrate Enumeration

11. Prior to processing any samples in a lot (i.e., samples within a collection date, specific watershed, or project), complete the sample log-in sheet to verify that all samples have arrived at the laboratory, and are in proper condition for processing.

12. Thoroughly rinse sample in a 500 μm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for given sample should be combined at this time. Gently mix the sample by hand while rinsing to make homogeneous.

13. Floating and picking the sample can be completed if there is an inordinate amount of organic debris within the sample. This can be completed by various methods as long as visible degradation on the organisms within the sample does not occur. There are a variety of flotation methods available and any one can be used, i.e. sugar or epsom salts. Other methodologies may be employed so long as the individual organisms within the samples are not significantly damaged which may hinder the identification process.

14. After washing, spread the sample evenly across a pan marked with grids approximately 6 cm x 6 cm. On the laboratory bench sheet, note the presence of large or obviously abundant organisms; do not remove them from the pan. However, Vinson and Hawkins (1996) present an argument for including these large organisms in the count, because of the high probability that these organisms will be excluded from the targeted grids.

15. Use a random numbers table to select 4 numbers corresponding to squares (grids) within the gridded pan. Remove all material (organisms and debris) from the four gird squares, and place the material into a shallow white pan and add a small amount of water to facilitate sorting. If there appear (through a cursory count or observation) to be 100 organisms ± 20% (cumulative of 4 grids), then subsampling is complete.

    Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organisms is considered to be in the gird containing most of its body.

    If the density of organisms is high enough that many more than 100/200/300 organisms are contained in the 4 grids, transfer the contents of the 4 grids to a second gridded pan. Randomly select grids for this second level of sorting as was done for the first, sorting grids one at a time until 100/200/300 organisms ± 20% are found. If picking through the entire next grid is likely to result in a subsample of greater than 120/240/360 organisms, then that grid may be subsampled in the sample manner as before to decrease the likelihood of exceeding 120/240/360 organisms. That is, spread the contents of the last grid into another gridded pan. Pick grids one at a time until the desired number is reached. The total number of grids for each subsorting level should be noted on the laboratory bench sheet.

16. Save the sorted debris residue in a separate container. Add a label that includes the words "sorted residue" in addition to all prior sample label information and preserve in 95% ethanol. Save the remaining unsorted sample debris residue in a separate container labeled "sample residue"; this container should include the original sample label. Length of storage and archival is determined by the laboratory or benthic section supervisor.

17. Place the sorted 100/200/300-organism (±20%) subsample into glass vials, and preserve in 70% ethanol. Label the vials inside with the sample identifier or lot number, date, stream name, sampling location and taxonomic group. If more than one vial is needed, each should be labeled separately and numbered (e.g., 1 of 2, 2 of 2). For convenience in reading the labels inside the vials, insert the labels left-edge first. If identification is to occur immediately after sorting, a petri dish or watch glass can be used instead of vials.

18. Midges (Chironomidae) should be mounted on slides in an appropriate medium (e.g., Euperal, CMC-10); slides should be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled.

19. Fill out header information on Laboratory Bench Sheet as in field sheets. Also check subsample target number. Complete back of sheet for subsampling/sorting information. Note number of grids picked, time expenditure, and number of organisms. If on the back of the laboratory Bench Sheet. Calculate sorting efficiency to determine whether sorting effort passes or fails.

20. Record date of sorting and slide monitoring, if applicable, on Log-In Sheet as documentation of progress and status of sample lot.

Quality Control (QC) for Sorting

3. Ten Percent of the sorted samples in each lot should be examined by laboratory QC personnel or a qualified co-worker. (A lot is defined as a special study, basin study, entire index period, or individual sorter.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials. If the QC worker finds less than 10 organisms (or 10% in larger subsamples) remaining in the grids or sorting tray, the sample passes; if more than 10 (or 10%) are found, the sample fails. If the first 10% of the sample lot fails, a second 10% of the sample lot will be checked by the QC worker. Sorter in-training will have their samples 100% checked until the trainer decides that training is complete.

4. After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

Identification of Macroinvertebrates

Taxonomy can be at any level, but should be consistent among samples. In the original RBPs, two levels of identification were suggested – family (RBP II) and genus/species (RBP

III) level (Plafkin et al. 1989). Genus/species will provide more accurate information on ecological/environmental relationships and sensitivity to impairment. Family level will provide a higher degree of precision among samples and taxonomists, requires less expertise to perform, and accelerates assessment results. In either case, only those taxonomic keys that have been peer reviewed and are published in some way to be available to other taxonomists should be used. Unnamed species (i.e., species A, B, 1 or 2) may be ecologically informative, but will contribute to variability and inconsistency when a statewide database is being developed.

6. Most organisms are identified to the lowest practical level (generally genus or species) by a qualified taxonomist using a dissecting microscope. Midges (Diptera: Chironomidae) are mounted on slides in an appropriate medium and identified using a compound microscope. Each taxon found in a sample is recorded and enumerated in a laboratory bench notebook and then transcribed to the laboratory bench sheet for subsequent reports. Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

7. Labels with specific taxa names (and taxonomist's initials) are added to the vials of specimens by the taxonomist. Individual specimens may be extracted from the sample to be included in a reference collection or to be verified by a 2nd taxonomist. Slides are initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.

8. Record the identity and number of organisms on the Laboratory Bench Sheet. Either a tally counter or "slash" marks on the bench sheet can be done to keep track of the cumulative count. Also, record the life stage of the organisms, taxonomist's initials and taxonomic certainty rating (TCR) as a measure of confidence.

9. Complete the back of the bench sheet to explain certain TCR ratings or condition of organisms. Other comments can be included to provide additional insights for data interpretation. If QC was performed, record on back of sheet.

10. For archiving samples, specimen vials, grouped by station and date, are placed in jars with a small amount of denatured 70% ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vials takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (denatured 70% ethanol).

Identification QA/QC Procedures of Macroinvertebrates

4. A voucher collection of all samples and subsamples should be maintained. These specimens should be properly labeled, preserved, and stored in the laboratory for future reference. A taxonomist (the reviewer) not responsible for the original identifications should spot check samples corresponding to the identifications on the bench sheet.

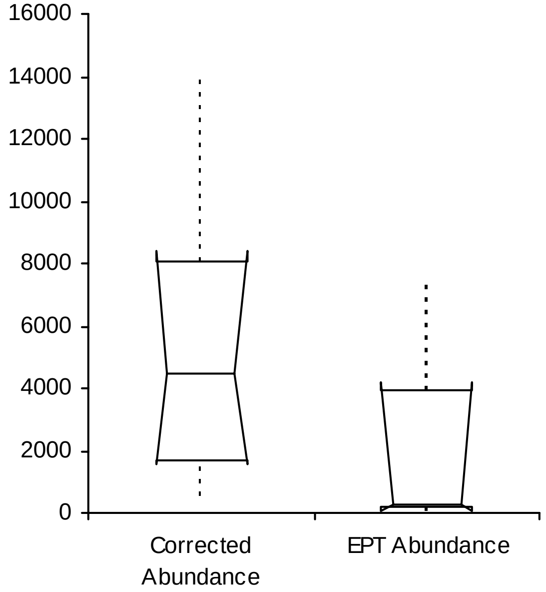
5. The reference collection of each identified taxon should also be maintained and verified by a second taxonomist. The word "val." and the 1st initial and last name of the person validating the identification should be added to the vial label. Specimens sent out for taxonomic validations should be recorded in a "Taxonomy Validation Notebook" showing the label information and the date sent out. Upon return of the specimens, the date received and the

finding should also be recorded in the notebook along with the name of the person who performed the validation.

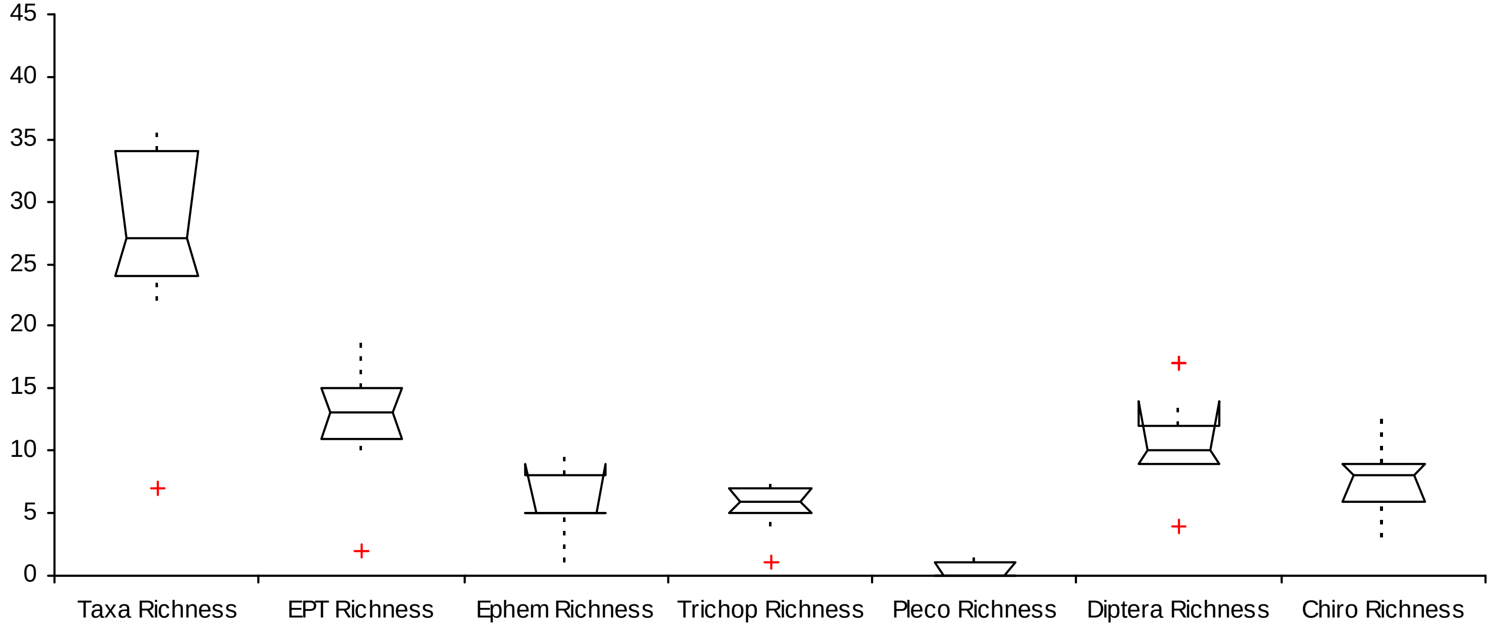
6. Information on samples completed (through the identification process) will be recorded in the "sample log" notebook to track the progress of each sample within the sample lot. Tracking of each sample will be updated as each step is completed (i.e., subsampling and sorting, mounting of midges and worms, taxonomy).

Appendix L.
Box Plots of Macroinvertebrate Metrics

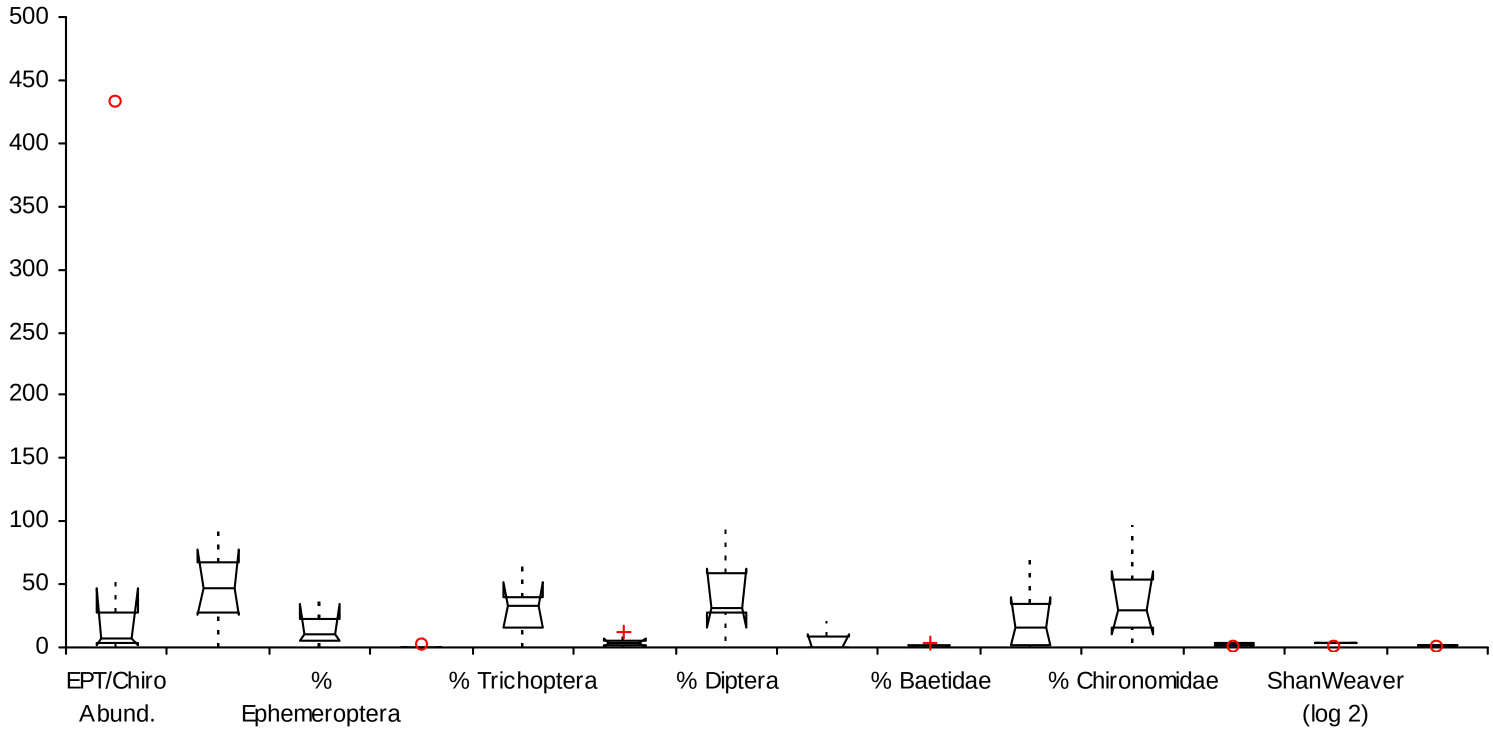
Box Plots of Macroinvertebrates – Rivers



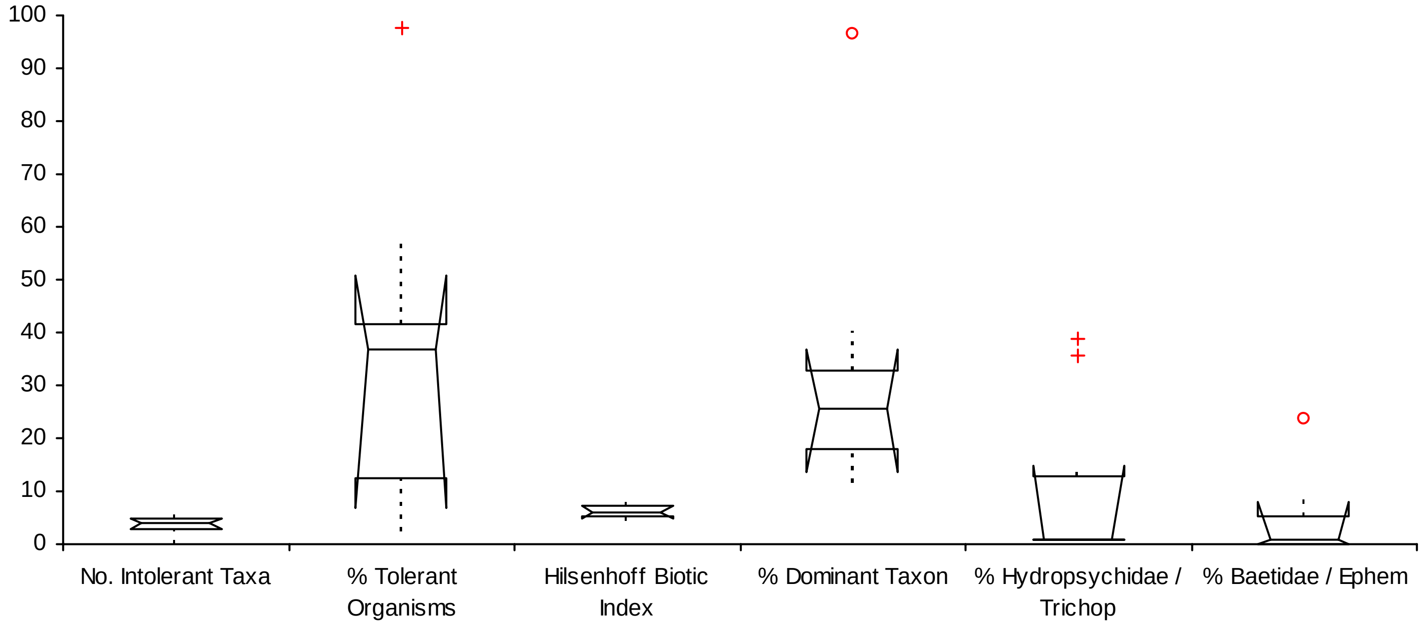
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
Corrected Abundance	13	0.812	5144.2	4175.38	1158.04	2621.0	to 7667.3	4455.0	6387.3	1557.7	to 8400.0
EPT Abundance	13	1.318	1809.5	2385.74	661.69	367.8	to 3251.2	276.0	3760.0	96.0	to 4200.0



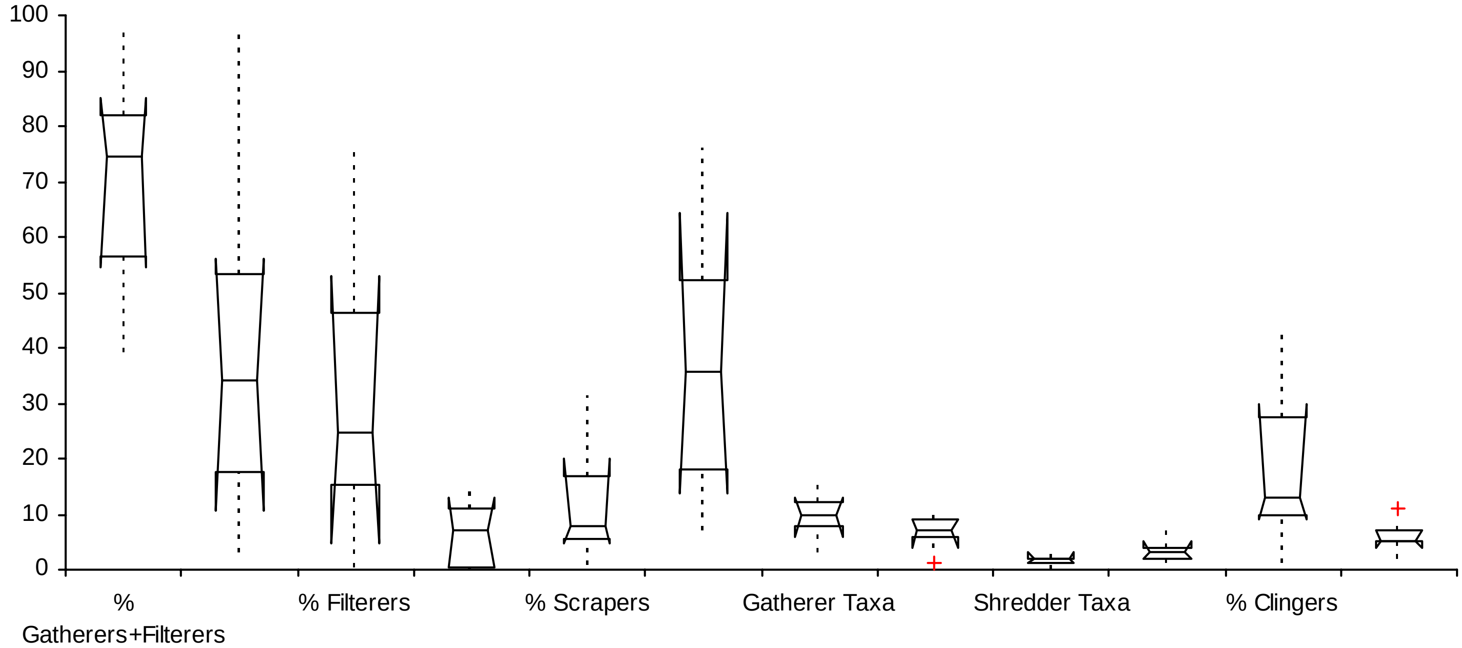
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
Taxa Richness	13	0.285	27.5	7.84	2.17	22.7	to 32.2	27.0	10.0	24.0	to 34.0
EPT Richness	13	0.323	12.5	4.05	1.12	10.1	to 15.0	13.0	4.0	11.0	to 15.0
Ephem Richness	13	0.419	6.2	2.58	0.71	4.6	to 7.7	5.0	3.0	5.0	to 9.0
Trichop Richness	13	0.310	5.8	1.79	0.50	4.7	to 6.8	6.0	2.0	5.0	to 7.0
Pleco Richness	13	1.248	0.6	0.77	0.21	0.2	to 1.1	0.0	1.0	0.0	to 1.0
Diptera Richness	13	0.316	11.077	3.4991	0.9705	9.0	to 13.2	10.000	3.000	9.0	to 14.0
Chiro Richness	13	0.311	7.7	2.39	0.66	6.2	to 9.1	8.0	3.0	6.0	to 9.0



	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
EPT/Chiro Abund.	13	2.501	46.848	117.1801	32.4999	-23.963	to 117.659	6.330	24.414	0.947	to 46.790
% EPT	13	0.566	47.776	27.0625	7.5058	31.422	to 64.130	46.790	40.370	25.590	to 77.470
% Ephemeroptera	13	0.850	15.163	12.8881	3.5745	7.375	to 22.951	10.980	18.330	4.460	to 34.360
% Plecoptera	13	1.754	0.342	0.6003	0.1665	-0.020	to 0.705	0.000	0.370	0.000	to 0.640
% Trichoptera	13	0.679	32.272	21.9244	6.0807	19.023	to 45.520	33.440	24.050	15.410	to 52.040
% Coleoptera	13	0.955	3.803	3.6303	1.0069	1.609	to 5.997	2.870	3.860	0.860	to 6.790
% Diptera	13	0.646	41.328	26.7071	7.4072	25.190	to 57.467	31.430	31.020	15.430	to 62.630
% Oligochaeta	13	1.412	5.102	7.2015	1.9973	0.750	to 9.453	0.310	8.600	0.000	to 9.670
% Baetidae	13	1.284	0.632	0.8108	0.2249	0.142	to 1.122	0.310	0.890	0.000	to 1.230
% Hydropsychidae	13	1.034	21.242	21.9682	6.0929	7.966	to 34.517	14.810	33.450	1.710	to 39.940
% Chironomidae	13	0.757	36.172	27.3717	7.5915	19.631	to 52.712	29.280	37.820	10.190	to 60.610
ShanWeaver (log e)	13	0.302	2.333	0.7051	0.1956	1.907	to 2.759	2.480	0.490	2.170	to 2.740
ShanWeaver (log 2)	13	0.302	3.364	1.0163	0.2819	2.750	to 3.978	3.580	0.710	3.130	to 3.950
ShanWeaver (log 10)	13	0.301	1.014	0.3056	0.0848	0.829	to 1.199	1.080	0.220	0.940	to 1.190

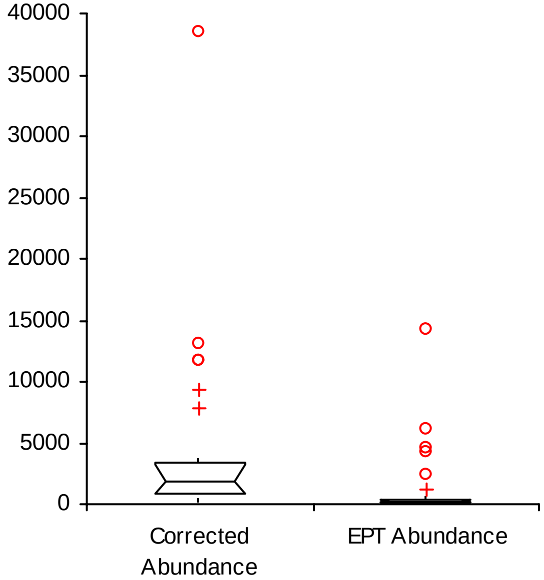


	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
No. Intolerant Taxa	13	0.409	3.923	1.6053	0.4452	2.953	to 4.893	4.000	2.000	3.000	to 5.000
% Tolerant Organisms	13	0.768	34.196	26.2514	7.2808	18.332	to 50.059	36.790	29.220	6.790	to 50.955
Hilsenhoff Biotic Index	13	0.187	6.127	1.1444	0.3174	5.435	to 6.818	6.140	1.920	4.880	to 7.210
% Dominant Taxon	13	0.730	30.105	21.9894	6.0988	16.817	to 43.393	25.700	14.671	13.497	to 36.943
% Hydropsychidae / Trichop	13	1.372	9.641	13.2292	3.6691	1.647	to 17.636	1.000	11.766	0.990	to 14.679
% Baetidae / Ephem	13	1.668	3.987	6.6512	1.8447	-0.032	to 8.007	0.893	4.930	0.030	to 8.108

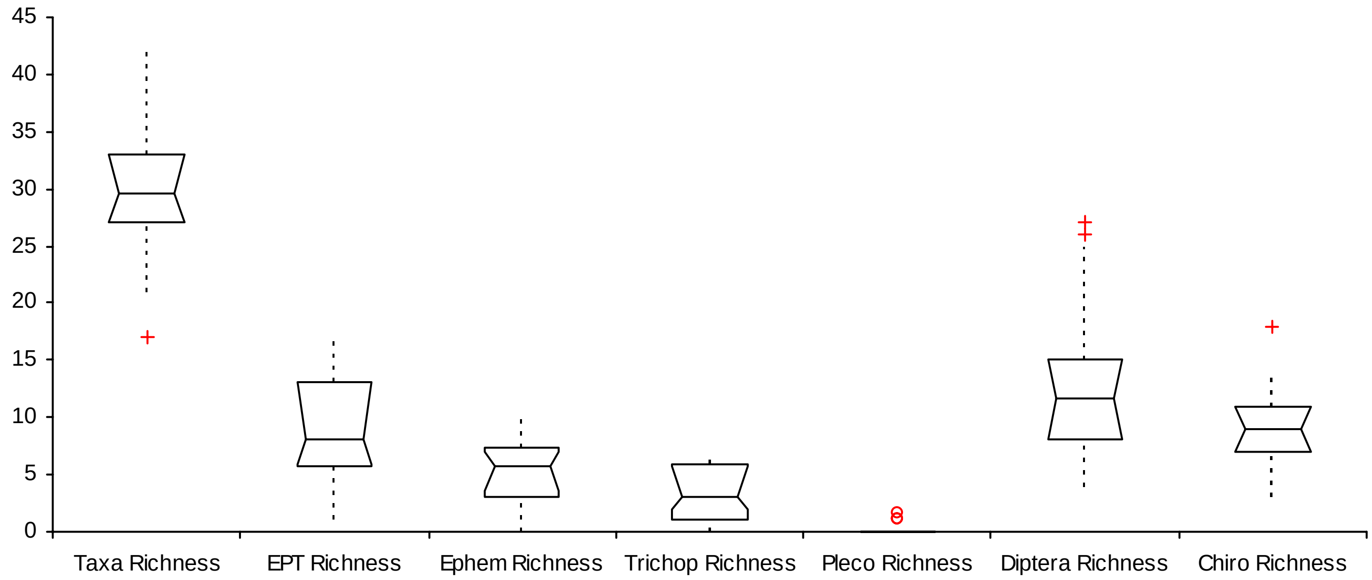


	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
% Gatherers+Filterers	13	0.260	69.560	18.0724	5.0124	58.639	to 80.481	74.620	25.760	54.630	to 84.950
% Gatherers	13	0.706	37.720	26.6150	7.3817	21.637	to 53.803	34.290	36.020	10.490	to 56.230
% Filterers	13	0.784	31.840	24.9733	6.9263	16.749	to 46.931	24.540	30.950	4.860	to 52.790
% Shredders	13	0.920	6.408	5.8981	1.6358	2.844	to 9.973	7.140	10.350	0.310	to 13.010
% Scrapers	13	0.746	11.796	8.7980	2.4401	6.480	to 17.113	7.860	11.460	4.640	to 19.900
Scrapers / (Scrapers+Filterers)	13	0.644	37.323	24.0471	6.6695	22.792	to 51.855	35.714	34.197	13.605	to 64.286
Gatherer Taxa	13	0.389	9.692	3.7724	1.0463	7.413	to 11.972	10.000	4.000	6.000	to 13.000
Filterer Taxa	13	0.405	6.769	2.7433	0.7609	5.111	to 8.427	7.000	3.000	4.000	to 9.000
Shredder Taxa	13	0.524	1.8	0.93	0.26	1.209	to 2.329	2.0	1.0	1.000	to 3.000
Scraper Taxa	13	0.484	3.3	1.60	0.44	2.340	to 4.275	3.0	2.0	2.000	to 5.000
% Clingers	13	0.706	18.767	13.2459	3.6738	10.762	to 26.771	12.773	17.600	8.930	to 29.938
Clinger Taxa	13	0.394	5.8	2.30	0.64	4.454	to 7.238	5.0	2.0	4.000	to 7.000

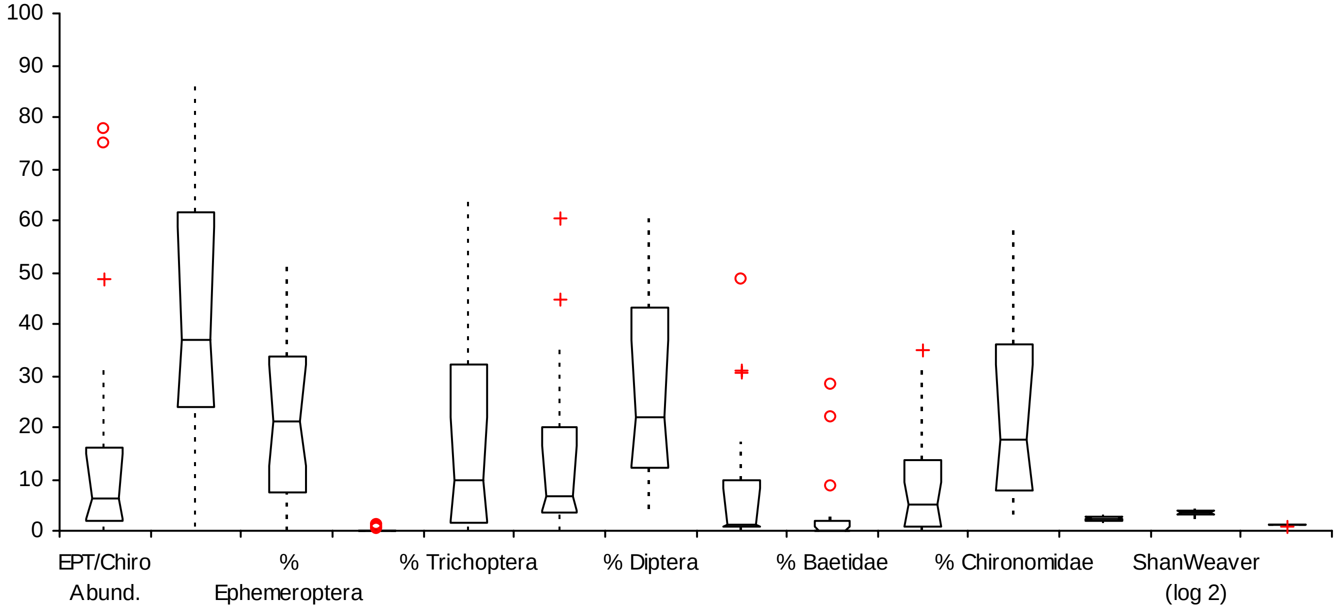
Box Plots of Macroinverts – Tribs



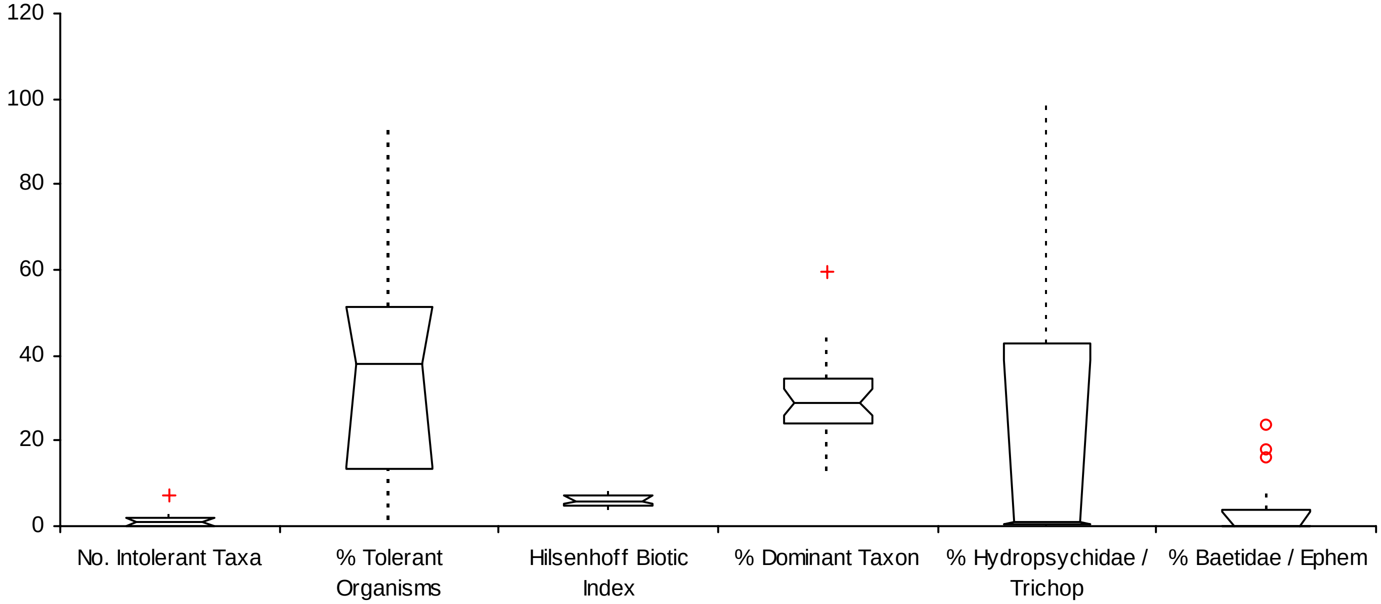
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
Corrected Abundance	29	1.699	4423.6	7515.50	1395.59	1564.9	to 7282.4	1789.7	2444.3	873.9	to 3250.0
EPT Abundance	29	2.280	1279.3	2916.76	541.63	169.8	to 2388.7	221.0	260.0	151.3	to 294.0



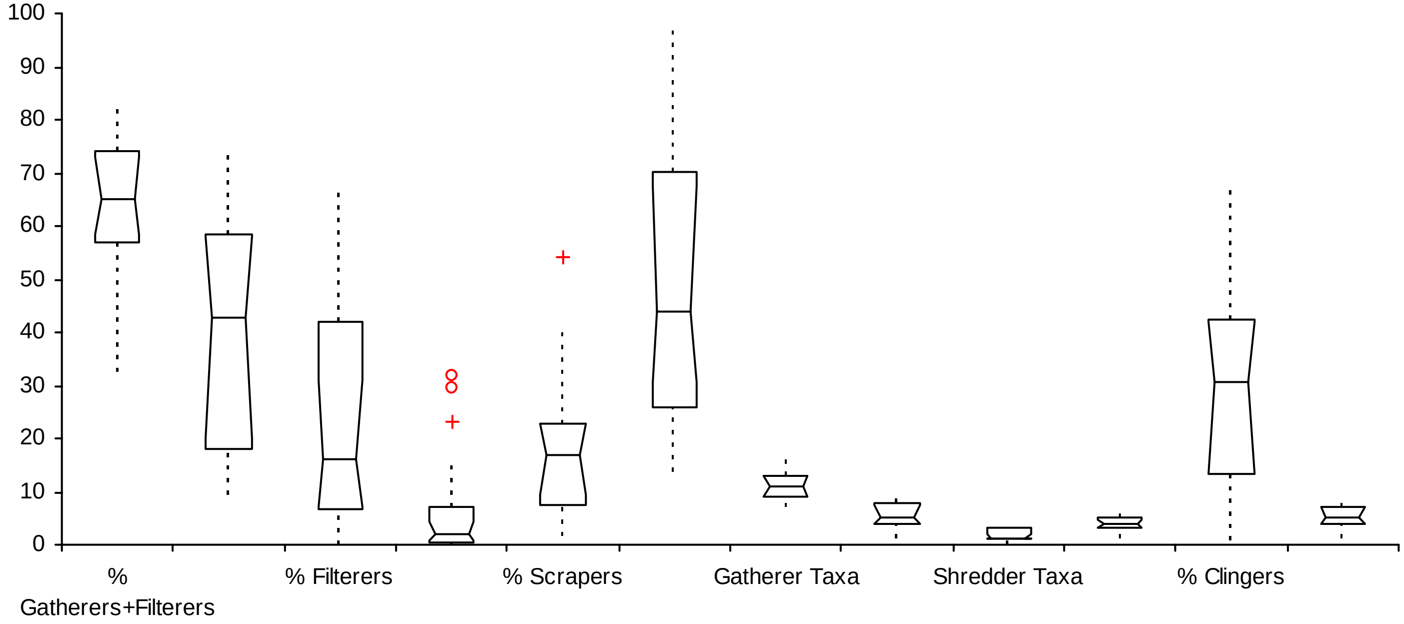
	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
Taxa Richness	29	0.188	29.4	5.53	1.03	27.3	to 31.5	29.7	6.0	27.0	to 33.0
EPT Richness	29	0.534	8.9	4.78	0.89	7.1	to 10.8	8.0	7.3	6.0	to 13.0
Ephem Richness	29	0.523	5.4	2.80	0.52	4.3	to 6.4	5.7	4.3	3.7	to 7.0
Trichop Richness	29	0.628	3.5	2.17	0.40	2.6	to 4.3	3.0	5.0	2.0	to 5.7
Pleco Richness	28	3.047	0.1	0.40	0.08	0.0	to 0.3	0.0	0.0	0.0	to 0
Diptera Richness	29	0.490	12.736	6.2376	1.1583	10.4	to 15.1	11.667	7.000	8.0	to 15.0
Chiro Richness	29	0.390	9.1	3.55	0.66	7.8	to 10.5	9.0	4.0	7.0	to 11.0



	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
EPT/Chiro Abund.	29	1.363	14.863	20.2567	3.7616	7.158	to 22.568	6.158	14.125	2.190	to 14.733
% EPT	29	0.674	41.193	27.7631	5.1555	30.633	to 51.754	37.040	37.670	24.060	to 58.820
% Ephemeroptera	29	0.659	21.757	14.3485	2.6645	16.299	to 27.215	21.000	26.230	12.420	to 32.190
% Plecoptera	29	3.300	0.068	0.2231	0.0414	-0.017	to 0.152	0.000	0.000	0.000	to 0
% Trichoptera	29	1.157	18.360	21.2477	3.9456	10.278	to 26.443	10.000	30.420	1.930	to 21.920
% Coleoptera	29	1.084	13.300	14.4221	2.6781	7.814	to 18.786	6.800	16.370	3.750	to 16.390
% Diptera	29	0.717	26.532	19.0227	3.5324	19.297	to 33.768	22.000	31.120	12.420	to 36.910
% Oligochaeta	29	1.596	7.366	11.7594	2.1837	2.893	to 11.839	1.290	9.000	0.630	to 8.260
% Baetidae	29	2.566	2.557	6.5607	1.2183	0.061	to 5.052	0.000	2.000	0.000	to 0.970
% Hydropsychidae	29	1.234	8.604	10.6200	1.9721	4.565	to 12.644	5.000	12.990	0.720	to 9.420
% Chironomidae	29	0.788	22.589	17.7970	3.3048	15.819	to 29.359	17.540	28.310	8.000	to 32.250
ShanWeaver (log e)	29	0.144	2.414	0.3478	0.0646	2.282	to 2.547	2.450	0.580	2.230	to 2.660
ShanWeaver (log 2)	29	0.130	3.527	0.4597	0.0854	3.352	to 3.702	3.550	0.700	3.240	to 3.850
ShanWeaver (log 10)	29	0.115	1.061	0.1225	0.0227	1.014	to 1.107	1.050	0.150	1.000	to 1.140



	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
No. Intolerant Taxa	29	1.303	1.414	1.8423	0.3421	0.713	to 2.115	1.000	2.000	0.000	to 2.000
% Tolerant Organisms	29	0.752	37.607	28.2920	5.2537	26.845	to 48.369	37.760	37.950	13.980	to 51.350
Hilsenhoff Biotic Index	29	0.198	6.131	1.2111	0.2249	5.670	to 6.592	5.920	2.100	5.300	to 7.020
% Dominant Taxon	29	0.332	29.809	9.8896	1.8365	26.047	to 33.571	28.623	10.563	25.828	to 31.965
% Hydropsychidae / Trichop	29	1.334	21.681	28.9249	5.3712	10.679	to 32.684	1.000	42.179	0.470	to 39.116
% Baetidae / Ephem	29	1.873	3.201	5.9944	1.1131	0.920	to 5.481	0.170	3.846	0.000	to 3.175



	n	CV	Mean	SD	SE	95% CI of Mean		Median	IQR	95% CI of Median	
% Gatherers+Filterers	29	0.232	63.277	14.7047	2.7306	57.683	to 68.870	65.070	17.030	58.510	to 72.820
% Gatherers	29	0.557	39.793	22.1464	4.1125	31.369	to 48.217	42.810	40.360	20.000	to 58.160
% Filterers	29	0.916	23.483	21.5135	3.9950	15.300	to 31.666	16.000	35.380	7.070	to 31.160
% Shredders	29	1.545	5.668	8.7544	1.6257	2.338	to 8.998	1.900	6.670	0.900	to 4.420
% Scrapers	29	0.717	17.759	12.7279	2.3635	12.918	to 22.600	16.880	15.300	9.600	to 22.600
Scrapers / (Scrapers+Filterers)	29	0.502	49.918	25.0415	4.6501	40.393	to 59.443	44.104	44.306	30.451	to 67.550
Gatherer Taxa	29	0.258	10.862	2.7995	0.5199	9.797	to 11.927	11.000	4.000	9.000	to 13.000
Filterer Taxa	29	0.495	5.471	2.7057	0.5024	4.442	to 6.500	5.000	3.670	4.000	to 7.330
Shredder Taxa	29	0.608	1.6	1.00	0.19	1.263	to 2.024	1.3	2.0	1.000	to 2.000
Scraper Taxa	29	0.349	4.1	1.43	0.27	3.558	to 4.649	4.0	2.0	3.000	to 4.667
% Clingers	29	0.682	28.325	19.3201	3.5877	20.976	to 35.674	30.740	28.935	13.350	to 41.910
Clinger Taxa	29	0.421	5.3	2.23	0.41	4.455	to 6.154	5.0	3.0	4.000	to 7.000

Appendix M.
Score Sheets for Macroinvertebrates – Tributary Sites

Score Sheets for Macroinvertebrates – Tributaries

Site T04

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	289	69
Taxa Richness	Decrease	95th	37.8	33	87
Trichop Richness	Decrease	95th	6.4	0	0
Diptera Richness	Decrease	95th	25.6	27	100
% EPT	Decrease	95th	83.83	1.04	1
% Chironomidae	Increase	5th	3.47	51.21	51
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.16	97
% Tolerant	Increase	5th	3.89	79.93	21
HBI	Increase	5th	4.66	8.48	28
% Dominant	Increase	5th	14.94	26.99	86
% Gatherers	Decrease	95th	69.38	71.97	100
% Filterers	Increase	5th	1.96	8.65	93
% Scrapers	Decrease	95th	38.4	1.38	4
% Clingers	Decrease	95th	59.92	3	5
			Final index value for this site:		**53**

Site T05

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	311	75
Taxa Richness	Decrease	95th	37.8	31	82
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	15	59
% EPT	Decrease	95th	83.83	25.08	30
% Chironomidae	Increase	5th	3.47	59.16	42
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.15	97
% Tolerant	Increase	5th	3.89	13.50	90
HBI	Increase	5th	4.66	5.47	85
% Dominant	Increase	5th	14.94	21.86	92
% Gatherers	Decrease	95th	69.38	25.40	37
% Filterers	Increase	5th	1.96	7.07	95
% Scrapers	Decrease	95th	38.4	7.40	19
% Clingers	Decrease	95th	59.92	14	24
			Final index value for this site:		**66**

Site T06

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	327	78
Taxa Richness	Decrease	95th	37.8	30	79
Trichop Richness	Decrease	95th	6.4	4	63
Diptera Richness	Decrease	95th	25.6	16	63
% EPT	Decrease	95th	83.83	47.09	56
% Chironomidae	Increase	5th	3.47	38.84	63
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.18	99
% Tolerant	Increase	5th	3.89	13.98	90
HBI	Increase	5th	4.66	5.62	82
% Dominant	Increase	5th	14.94	20.49	93
% Gatherers	Decrease	95th	69.38	62.69	90
% Filterers	Increase	5th	1.96	11.31	90
% Scrapers	Decrease	95th	38.4	1.53	4
% Clingers	Decrease	95th	59.92	13	22
			Final index value for this site:		**70**

Site T07

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	305	73
Taxa Richness	Decrease	95th	37.8	28	74
Trichop Richness	Decrease	95th	6.4	3	47
Diptera Richness	Decrease	95th	25.6	15	59
% EPT	Decrease	95th	83.83	10.16	12
% Chironomidae	Increase	5th	3.47	52.46	49
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.07	90
% Tolerant	Increase	5th	3.89	72.10	29
HBI	Increase	5th	4.66	6.15	72
% Dominant	Increase	5th	14.94	28.52	84
% Gatherers	Decrease	95th	69.38	60.66	87
% Filterers	Increase	5th	1.96	21.31	80
% Scrapers	Decrease	95th	38.4	11.15	29
% Clingers	Decrease	95th	59.92	18	30
			Final index value for this site:		**58**

Site T08

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	339	81
Taxa Richness	Decrease	95th	37.8	30	79
Trichop Richness	Decrease	95th	6.4	2	31
Diptera Richness	Decrease	95th	25.6	17	66
% EPT	Decrease	95th	83.83	36.88	44
% Chironomidae	Increase	5th	3.47	56.88	45
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.14	96
% Tolerant	Increase	5th	3.89	51.35	51
HBI	Increase	5th	4.66	5.60	82
% Dominant	Increase	5th	14.94	14.69	100
% Gatherers	Decrease	95th	69.38	42.81	62
% Filterers	Increase	5th	1.96	21.88	80
% Scrapers	Decrease	95th	38.4	5.63	15
% Clingers	Decrease	95th	59.92	18	29
			Final index value for this site:		**62**

Site T09

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	294	71
Taxa Richness	Decrease	95th	37.8	42	100
Trichop Richness	Decrease	95th	6.4	3	47
Diptera Richness	Decrease	95th	25.6	26	100
% EPT	Decrease	95th	83.83	6.12	7
% Chironomidae	Increase	5th	3.47	21.43	81
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.26	100
% Tolerant	Increase	5th	3.89	37.76	65
HBI	Increase	5th	4.66	7.23	52
% Dominant	Increase	5th	14.94	26.19	87
% Gatherers	Decrease	95th	69.38	58.16	84
% Filterers	Increase	5th	1.96	7.82	94
% Scrapers	Decrease	95th	38.4	11.56	30
% Clingers	Decrease	95th	59.92	7	12
			Final index value for this site:		**66**

Site T10

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	138	33
Taxa Richness	Decrease	95th	37.8	17	45
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	13	51
% EPT	Decrease	95th	83.83	0.72	1
% Chironomidae	Increase	5th	3.47	36.23	66
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.91	76
% Tolerant	Increase	5th	3.89	51.45	51
HBI	Increase	5th	4.66	7.15	53
% Dominant	Increase	5th	14.94	23.19	90
% Gatherers	Decrease	95th	69.38	32.61	47
% Filterers	Increase	5th	1.96	0.72	100
% Scrapers	Decrease	95th	38.4	1.45	4
% Clingers	Decrease	95th	59.92	1	1
			Final index value for this site:		**45**

Site T11

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	309	74
Taxa Richness	Decrease	95th	37.8	27	71
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	11	43
% EPT	Decrease	95th	83.83	58.82	70
% Chironomidae	Increase	5th	3.47	18.89	84
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.05	88
% Tolerant	Increase	5th	3.89	39.44	63
HBI	Increase	5th	4.66	5.56	83
% Dominant	Increase	5th	14.94	27.86	85
% Gatherers	Decrease	95th	69.38	44.27	64
% Filterers	Increase	5th	1.96	14.24	87
% Scrapers	Decrease	95th	38.4	22.60	59
% Clingers	Decrease	95th	59.92	22	37
			Final index value for this site:		**72**

Site T12

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	276	66
Taxa Richness	Decrease	95th	37.8	36	95
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	18	70
% EPT	Decrease	95th	83.83	33.70	40
% Chironomidae	Increase	5th	3.47	32.25	70
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.29	100
% Tolerant	Increase	5th	3.89	39.64	63
HBI	Increase	5th	4.66	5.74	80
% Dominant	Increase	5th	14.94	13.04	100
% Gatherers	Decrease	95th	69.38	15.94	23
% Filterers	Increase	5th	1.96	17.75	84
% Scrapers	Decrease	95th	38.4	36.96	96
% Clingers	Decrease	95th	59.92	37	62
			Final index value for this site:		**75**

Site T13

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	291	70
Taxa Richness	Decrease	95th	37.8	27	71
Trichop Richness	Decrease	95th	6.4	3	47
Diptera Richness	Decrease	95th	25.6	15	59
% EPT	Decrease	95th	83.83	36.64	44
% Chironomidae	Increase	5th	3.47	46.92	55
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.00	84
% Tolerant	Increase	5th	3.89	38.67	64
HBI	Increase	5th	4.66	5.92	76
% Dominant	Increase	5th	14.94	29.11	83
% Gatherers	Decrease	95th	69.38	23.29	34
% Filterers	Increase	5th	1.96	31.16	70
% Scrapers	Decrease	95th	38.4	7.19	19
% Clingers	Decrease	95th	59.92	31	53
			Final index value for this site:		**59**

Site T14

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	325	78
Taxa Richness	Decrease	95th	37.8	33	87
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	25	98
% EPT	Decrease	95th	83.83	5.54	7
% Chironomidae	Increase	5th	3.47	17.54	85
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.02	86
% Tolerant	Increase	5th	3.89	41.54	61
HBI	Increase	5th	4.66	7.02	56
% Dominant	Increase	5th	14.94	43.38	67
% Gatherers	Decrease	95th	69.38	70.77	100
% Filterers	Increase	5th	1.96	6.15	96
% Scrapers	Decrease	95th	38.4	3.08	8
% Clingers	Decrease	95th	59.92	42	70
			Final index value for this site:		**65**

Site T15

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	1038	100
Taxa Richness	Decrease	95th	37.8	34	90
Trichop Richness	Decrease	95th	6.4	2	31
Diptera Richness	Decrease	95th	25.6	13	51
% EPT	Decrease	95th	83.83	7.03	8
% Chironomidae	Increase	5th	3.47	9.92	93
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.74	62
% Tolerant	Increase	5th	3.89	27.26	76
HBI	Increase	5th	4.66	6.75	61
% Dominant	Increase	5th	14.94	59.63	47
% Gatherers	Decrease	95th	69.38	74.76	100
% Filterers	Increase	5th	1.96	0.19	100
% Scrapers	Decrease	95th	38.4	5.80	15
% Clingers	Decrease	95th	59.92	60	100
			Final index value for this site:		**67**

Site T17

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	291	70
Taxa Richness	Decrease	95th	37.8	21	56
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	4	16
% EPT	Decrease	95th	83.83	6.19	7
% Chironomidae	Increase	5th	3.47	3.09	100
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.97	82
% Tolerant	Increase	5th	3.89	92.78	8
HBI	Increase	5th	4.66	8.39	30
% Dominant	Increase	5th	14.94	28.18	84
% Gatherers	Decrease	95th	69.38	68.04	98
% Filterers	Increase	5th	1.96	2.41	100
% Scrapers	Decrease	95th	38.4	18.20	47
% Clingers	Decrease	95th	59.92	3	5
			Final index value for this site:		**51**

Site T18

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	335	80
Taxa Richness	Decrease	95th	37.8	29	77
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	5	20
% EPT	Decrease	95th	83.83	9.55	11
% Chironomidae	Increase	5th	3.47	4.78	99
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.97	82
% Tolerant	Increase	5th	3.89	85.67	15
HBI	Increase	5th	4.66	7.95	38
% Dominant	Increase	5th	14.94	37.61	73
% Gatherers	Decrease	95th	69.38	57.01	82
% Filterers	Increase	5th	1.96	8.06	94
% Scrapers	Decrease	95th	38.4	22.40	58
% Clingers	Decrease	95th	59.92	4	6
			Final index value for this site:		**54**

Site T19

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	302	72
Taxa Richness	Decrease	95th	37.8	24	63
Trichop Richness	Decrease	95th	6.4	3	47
Diptera Richness	Decrease	95th	25.6	10	39
% EPT	Decrease	95th	83.83	23.80	28
% Chironomidae	Increase	5th	3.47	19.83	83
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.97	82
% Tolerant	Increase	5th	3.89	33.43	69
HBI	Increase	5th	4.66	6.63	63
% Dominant	Increase	5th	14.94	28.62	84
% Gatherers	Decrease	95th	69.38	45.59	66
% Filterers	Increase	5th	1.96	4.85	97
% Scrapers	Decrease	95th	38.4	10.41	27
% Clingers	Decrease	95th	59.92	31	51
			Final index value for this site:		**62**

Site T20

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	325	78
Taxa Richness	Decrease	95th	37.8	22	58
Trichop Richness	Decrease	95th	6.4	3	47
Diptera Richness	Decrease	95th	25.6	6	23
% EPT	Decrease	95th	83.83	61.47	73
% Chironomidae	Increase	5th	3.47	15.98	87
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.89	75
% Tolerant	Increase	5th	3.89	21.98	81
HBI	Increase	5th	4.66	5.37	87
% Dominant	Increase	5th	14.94	43.15	67
% Gatherers	Decrease	95th	69.38	19.65	28
% Filterers	Increase	5th	1.96	16.21	85
% Scrapers	Decrease	95th	38.4	53.60	100
% Clingers	Decrease	95th	59.92	59	99
			Final index value for this site:		**71**

Site T21

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	315	76
Taxa Richness	Decrease	95th	37.8	35	93
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	6	23
% EPT	Decrease	95th	83.83	81.90	98
% Chironomidae	Increase	5th	3.47	5.08	98
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.18	99
% Tolerant	Increase	5th	3.89	6.67	97
HBI	Increase	5th	4.66	4.80	97
% Dominant	Increase	5th	14.94	20.32	94
% Gatherers	Decrease	95th	69.38	9.52	14
% Filterers	Increase	5th	1.96	46.98	54
% Scrapers	Decrease	95th	38.4	34.60	90
% Clingers	Decrease	95th	59.92	49	81
			Final index value for this site:		**79**

Site T22

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	324	78
Taxa Richness	Decrease	95th	37.8	21	56
Trichop Richness	Decrease	95th	6.4	2	31
Diptera Richness	Decrease	95th	25.6	6	23
% EPT	Decrease	95th	83.83	46.62	56
% Chironomidae	Increase	5th	3.47	19.74	83
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.83	70
% Tolerant	Increase	5th	3.89	40.62	62
HBI	Increase	5th	4.66	6.44	67
% Dominant	Increase	5th	14.94	34.83	77
% Gatherers	Decrease	95th	69.38	41.47	60
% Filterers	Increase	5th	1.96	20.66	81
% Scrapers	Decrease	95th	38.4	32.22	84
% Clingers	Decrease	95th	59.92	40	66
			Final index value for this site:		**64**

Site T23

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	341	82
Taxa Richness	Decrease	95th	37.8	29	77
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	10	39
% EPT	Decrease	95th	83.83	86.22	100
% Chironomidae	Increase	5th	3.47	7.92	95
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.03	87
% Tolerant	Increase	5th	3.89	6.74	97
HBI	Increase	5th	4.66	4.97	94
% Dominant	Increase	5th	14.94	31.96	80
% Gatherers	Decrease	95th	69.38	13.78	20
% Filterers	Increase	5th	1.96	67.16	33
% Scrapers	Decrease	95th	38.4	16.40	43
% Clingers	Decrease	95th	59.92	47	78
			Final index value for this site:		**73**

Site T24

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	330	79
Taxa Richness	Decrease	95th	37.8	27	71
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	8	31
% EPT	Decrease	95th	83.83	35.45	42
% Chironomidae	Increase	5th	3.47	5.76	98
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.07	90
% Tolerant	Increase	5th	3.89	84.55	16
HBI	Increase	5th	4.66	7.61	45
% Dominant	Increase	5th	14.94	34.55	77
% Gatherers	Decrease	95th	69.38	52.73	76
% Filterers	Increase	5th	1.96	4.24	98
% Scrapers	Decrease	95th	38.4	19.70	51
% Clingers	Decrease	95th	59.92	1	2
			Final index value for this site:		**57**

Site T25

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	320	77
Taxa Richness	Decrease	95th	37.8	31	82
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	21	82
% EPT	Decrease	95th	83.83	24.06	29
% Chironomidae	Increase	5th	3.47	32.19	70
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.21	100
% Tolerant	Increase	5th	3.89	63.13	38
HBI	Increase	5th	4.66	7.10	54
% Dominant	Increase	5th	14.94	15.31	100
% Gatherers	Decrease	95th	69.38	64.06	92
% Filterers	Increase	5th	1.96	3.75	98
% Scrapers	Decrease	95th	38.4	16.88	44
% Clingers	Decrease	95th	59.92	12	20
			Final index value for this site:		**64**

Site T26

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	317	76
Taxa Richness	Decrease	95th	37.8	31	82
Trichop Richness	Decrease	95th	6.4	1	16
Diptera Richness	Decrease	95th	25.6	14	55
% EPT	Decrease	95th	83.83	39.43	47
% Chironomidae	Increase	5th	3.47	36.59	66
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.11	93
% Tolerant	Increase	5th	3.89	78.23	23
HBI	Increase	5th	4.66	7.57	46
% Dominant	Increase	5th	14.94	29.97	82
% Gatherers	Decrease	95th	69.38	58.36	84
% Filterers	Increase	5th	1.96	6.62	95
% Scrapers	Decrease	95th	38.4	22.70	59
% Clingers	Decrease	95th	59.92	13	22
			Final index value for this site:		**60**

Site T27

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	467	100
Taxa Richness	Decrease	95th	37.8	39	100
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	15	59
% EPT	Decrease	95th	83.83	37.04	44
% Chironomidae	Increase	5th	3.47	16.92	86
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.23	100
% Tolerant	Increase	5th	3.89	25.48	78
HBI	Increase	5th	4.66	6.00	75
% Dominant	Increase	5th	14.94	23.98	89
% Gatherers	Decrease	95th	69.38	49.46	71
% Filterers	Increase	5th	1.96	27.41	74
% Scrapers	Decrease	95th	38.4	9.60	25
% Clingers	Decrease	95th	59.92	42	70
			Final index value for this site:		**76**

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	317	76
Taxa Richness	Decrease	95th	37.8	34	90
Trichop Richness	Decrease	95th	6.4	5	78
Diptera Richness	Decrease	95th	25.6	12	47
% EPT	Decrease	95th	83.83	58.57	70
% Chironomidae	Increase	5th	3.47	10.41	93
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.15	97
% Tolerant	Increase	5th	3.89	14.48	89
HBI	Increase	5th	4.66	5.28	88
% Dominant	Increase	5th	14.94	30.76	81
% Gatherers	Decrease	95th	69.38	18.47	27
% Filterers	Increase	5th	1.96	41.86	59
% Scrapers	Decrease	95th	38.4	31.05	81
% Clingers	Decrease	95th	59.92	35	59
			Final index value for this site:		**74**

Site T29

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	330	79
Taxa Richness	Decrease	95th	37.8	23	61
Trichop Richness	Decrease	95th	6.4	3	47
Diptera Richness	Decrease	95th	25.6	8	31
% EPT	Decrease	95th	83.83	66.97	80
% Chironomidae	Increase	5th	3.47	4.55	99
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.84	71
% Tolerant	Increase	5th	3.89	1.52	100
HBI	Increase	5th	4.66	4.72	99
% Dominant	Increase	5th	14.94	44.55	65
% Gatherers	Decrease	95th	69.38	14.85	21
% Filterers	Increase	5th	1.96	56.06	45
% Scrapers	Decrease	95th	38.4	24.50	64
% Clingers	Decrease	95th	59.92	30	50
			Final index value for this site:		**65**

Site T30

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	338	81
Taxa Richness	Decrease	95th	37.8	26	69
Trichop Richness	Decrease	95th	6.4	6	94
Diptera Richness	Decrease	95th	25.6	8	31
% EPT	Decrease	95th	83.83	83.23	99
% Chironomidae	Increase	5th	3.47	5.70	98
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	0.95	80
% Tolerant	Increase	5th	3.89	8.02	96
HBI	Increase	5th	4.66	5.09	92
% Dominant	Increase	5th	14.94	38.00	73
% Gatherers	Decrease	95th	69.38	13.00	19
% Filterers	Increase	5th	1.96	46.36	55
% Scrapers	Decrease	95th	38.4	32.14	84
% Clingers	Decrease	95th	59.92	67	100
			Final index value for this site:		**76**

Site T31

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	302	72
Taxa Richness	Decrease	95th	37.8	29	77
Trichop Richness	Decrease	95th	6.4	5	78
Diptera Richness	Decrease	95th	25.6	9	35
% EPT	Decrease	95th	83.83	71.85	86
% Chironomidae	Increase	5th	3.47	12.91	90
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.07	90
% Tolerant	Increase	5th	3.89	12.58	91
HBI	Increase	5th	4.66	5.30	88
% Dominant	Increase	5th	14.94	25.83	87
% Gatherers	Decrease	95th	69.38	23.51	34
% Filterers	Increase	5th	1.96	58.61	42
% Scrapers	Decrease	95th	38.4	15.20	40
% Clingers	Decrease	95th	59.92	45	75
			Final index value for this site:		**70**

Site T32

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	309	74
Taxa Richness	Decrease	95th	37.8	33	87
Trichop Richness	Decrease	95th	6.4	7	100
Diptera Richness	Decrease	95th	25.6	9	35
% EPT	Decrease	95th	83.83	82.85	99
% Chironomidae	Increase	5th	3.47	3.56	100
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.11	93
% Tolerant	Increase	5th	3.89	4.85	99
HBI	Increase	5th	4.66	4.70	99
% Dominant	Increase	5th	14.94	31.72	80
% Gatherers	Decrease	95th	69.38	10.36	15
% Filterers	Increase	5th	1.96	62.46	38
% Scrapers	Decrease	95th	38.4	20.10	52
% Clingers	Decrease	95th	59.92	31	52
			Final index value for this site:		**73**

Site T33

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	417	325	78
Taxa Richness	Decrease	95th	37.8	30	79
Trichop Richness	Decrease	95th	6.4	7	100
Diptera Richness	Decrease	95th	25.6	8	31
% EPT	Decrease	95th	83.83	80.59	96
% Chironomidae	Increase	5th	3.47	7.55	96
Shannon-Wiener Index (Log 10)	Decrease	95th	1.19	1.07	90
% Tolerant	Increase	5th	3.89	3.24	100
HBI	Increase	5th	4.66	4.49	100
% Dominant	Increase	5th	14.94	30.18	82
% Gatherers	Decrease	95th	69.38	10.68	15
% Filterers	Increase	5th	1.96	59.25	42
% Scrapers	Decrease	95th	38.4	16.98	44
% Clingers	Decrease	95th	59.92	42	70
			Final index value for this site:		**73**

Appendix N.
Score Sheets for Macroinvertebrates – River Sites

Score Sheets for Macroinvertebrates Metrics – Rivers

Site R01

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	280	76
Taxa Richness	Decrease	95th	36	31	86
EPT Richness	Decrease	95th	17.8	13	73
Trichop Richness	Decrease	95th	7.4	6	81
Chiro Richness	Decrease	95th	11.2	6	54
% EPT	Decrease	95th	80.79	46.79	58
% Coleoptera	Decrease	95th	9.26	0.71	8
% Chironomidae	Increase	5th	6.55	30	75
Intolerant Richness	Decrease	95th	5.4	5	93
% Tolerant	Increase	5th	4.04	36.79	66
% Dominant	Increase	5th	12.45	20	91
Gatherer Richness	Decrease	95th	14.8	16.00	100
Scraper Richness	Decrease	95th	5.8	3	52
Clinger Richness	Decrease	95th	9.8	4	41
			Final index value for this site:		**68**

Site R02

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	269	73
Taxa Richness	Decrease	95th	36	27	75
EPT Richness	Decrease	95th	17.8	12	67
Trichop Richness	Decrease	95th	7.4	7	95
Chiro Richness	Decrease	95th	11.2	6	54
% EPT	Decrease	95th	80.79	56.88	70
% Coleoptera	Decrease	95th	9.26	2.60	28
% Chironomidae	Increase	5th	6.55	29	76
Intolerant Richness	Decrease	95th	5.4	4	74
% Tolerant	Increase	5th	4.04	20.82	83
% Dominant	Increase	5th	12.45	21.19	90
Gatherer Richness	Decrease	95th	14.8	12.00	81
Scraper Richness	Decrease	95th	5.8	2	34
Clinger Richness	Decrease	95th	9.8	6	61
			Final index value for this site:		**69**

Site R03

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	279	76
Taxa Richness	Decrease	95th	36	24	67
EPT Richness	Decrease	95th	17.8	10	56
Trichop Richness	Decrease	95th	7.4	5	68
Chiro Richness	Decrease	95th	11.2	7	63
% EPT	Decrease	95th	80.79	20.43	25
% Coleoptera	Decrease	95th	9.26	2.87	31
% Chironomidae	Increase	5th	6.55	65	38
Intolerant Richness	Decrease	95th	5.4	3	56
% Tolerant	Increase	5th	4.04	40.50	62
% Dominant	Increase	5th	12.45	40.5	68
Gatherer Richness	Decrease	95th	14.8	10.00	68
Scraper Richness	Decrease	95th	5.8	3	52
Clinger Richness	Decrease	95th	9.8	5	51
			Final index value for this site:		**56**

Site R04

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	323	88
Taxa Richness	Decrease	95th	36	26	72
EPT Richness	Decrease	95th	17.8	12	67
Trichop Richness	Decrease	95th	7.4	6	81
Chiro Richness	Decrease	95th	11.2	10	89
% EPT	Decrease	95th	80.79	43.34	54
% Coleoptera	Decrease	95th	9.26	3.10	33
% Chironomidae	Increase	5th	6.55	47	56
Intolerant Richness	Decrease	95th	5.4	2	37
% Tolerant	Increase	5th	4.04	41.49	61
% Dominant	Increase	5th	12.45	25.7	85
Gatherer Richness	Decrease	95th	14.8	8.00	54
Scraper Richness	Decrease	95th	5.8	2	34
Clinger Richness	Decrease	95th	9.8	4	41
			Final index value for this site:		**61**

Site R05

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	350	100
Taxa Richness	Decrease	95th	36	7	19
EPT Richness	Decrease	95th	17.8	2	11
Trichop Richness	Decrease	95th	7.4	1	14
Chiro Richness	Decrease	95th	11.2	3	27
% EPT	Decrease	95th	80.79	0.57	1
% Coleoptera	Decrease	95th	9.26	0.86	9
% Chironomidae	Increase	5th	6.55	97	3
Intolerant Richness	Decrease	95th	5.4	0	0
% Tolerant	Increase	5th	4.04	97.43	3
% Dominant	Increase	5th	12.45	96.29	4
Gatherer Richness	Decrease	95th	14.8	3.00	20
Scraper Richness	Decrease	95th	5.8	1	17
Clinger Richness	Decrease	95th	9.8	2	20
			Final index value for this site:		**18**

Site R06

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	394	100
Taxa Richness	Decrease	95th	36	22	61
EPT Richness	Decrease	95th	17.8	11	62
Trichop Richness	Decrease	95th	7.4	6	81
Chiro Richness	Decrease	95th	11.2	6	54
% EPT	Decrease	95th	80.79	93.15	100
% Coleoptera	Decrease	95th	9.26	1.27	14
% Chironomidae	Increase	5th	6.55	4	100
Intolerant Richness	Decrease	95th	5.4	5	93
% Tolerant	Increase	5th	4.04	2.54	100
% Dominant	Increase	5th	12.45	32.74	77
Gatherer Richness	Decrease	95th	14.8	5.00	34
Scraper Richness	Decrease	95th	5.8	3	52
Clinger Richness	Decrease	95th	9.8	5	51
			Final index value for this site:		**70**

Site R07

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	297	81
Taxa Richness	Decrease	95th	36	24	67
EPT Richness	Decrease	95th	17.8	11	62
Trichop Richness	Decrease	95th	7.4	5	68
Chiro Richness	Decrease	95th	11.2	8	71
% EPT	Decrease	95th	80.79	25.59	32
% Coleoptera	Decrease	95th	9.26	11.45	100
% Chironomidae	Increase	5th	6.55	61	42
Intolerant Richness	Decrease	95th	5.4	3	56
% Tolerant	Increase	5th	4.04	57.91	44
% Dominant	Increase	5th	12.45	31.31	78
Gatherer Richness	Decrease	95th	14.8	8.00	54
Scraper Richness	Decrease	95th	5.8	3	52
Clinger Richness	Decrease	95th	9.8	6	61
			Final index value for this site:		**62**

Site R08

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	326	89
Taxa Richness	Decrease	95th	36	34	94
EPT Richness	Decrease	95th	17.8	17	96
Trichop Richness	Decrease	95th	7.4	6	81
Chiro Richness	Decrease	95th	11.2	8	71
% EPT	Decrease	95th	80.79	68.10	84
% Coleoptera	Decrease	95th	9.26	0.92	10
% Chironomidae	Increase	5th	6.55	22	83
Intolerant Richness	Decrease	95th	5.4	5	93
% Tolerant	Increase	5th	4.04	12.27	91
% Dominant	Increase	5th	12.45	13.5	99
Gatherer Richness	Decrease	95th	14.8	11.00	74
Scraper Richness	Decrease	95th	5.8	5	86
Clinger Richness	Decrease	95th	9.8	5	51
			Final index value for this site:		**79**

Site R09

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	314	85
Taxa Richness	Decrease	95th	36	34	94
EPT Richness	Decrease	95th	17.8	15	84
Trichop Richness	Decrease	95th	7.4	4	54
Chiro Richness	Decrease	95th	11.2	9	80
% EPT	Decrease	95th	80.79	30.57	38
% Coleoptera	Decrease	95th	9.26	4.78	52
% Chironomidae	Increase	5th	6.55	54	49
Intolerant Richness	Decrease	95th	5.4	5	93
% Tolerant	Increase	5th	4.04	50.96	51
% Dominant	Increase	5th	12.45	36.94	72
Gatherer Richness	Decrease	95th	14.8	12.00	81
Scraper Richness	Decrease	95th	5.8	7	100
Clinger Richness	Decrease	95th	9.8	5	51
			Final index value for this site:		**70**

Site R10

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	337	92
Taxa Richness	Decrease	95th	36	25	69
EPT Richness	Decrease	95th	17.8	13	73
Trichop Richness	Decrease	95th	7.4	7	95
Chiro Richness	Decrease	95th	11.2	8	71
% EPT	Decrease	95th	80.79	81.90	100
% Coleoptera	Decrease	95th	9.26	10.09	100
% Chironomidae	Increase	5th	6.55	5	100
Intolerant Richness	Decrease	95th	5.4	5	93
% Tolerant	Increase	5th	4.04	5.04	99
% Dominant	Increase	5th	12.45	30.56	79
Gatherer Richness	Decrease	95th	14.8	6.00	41
Scraper Richness	Decrease	95th	5.8	3	52
Clinger Richness	Decrease	95th	9.8	7	71
			Final index value for this site:		**81**

Site R11

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	321	87
Taxa Richness	Decrease	95th	36	36	100
EPT Richness	Decrease	95th	17.8	13	73
Trichop Richness	Decrease	95th	7.4	8	100
Chiro Richness	Decrease	95th	11.2	13	100
% EPT	Decrease	95th	80.79	27.73	34
% Coleoptera	Decrease	95th	9.26	0.00	0
% Chironomidae	Increase	5th	6.55	29	76
Intolerant Richness	Decrease	95th	5.4	4	74
% Tolerant	Increase	5th	4.04	41.43	61
% Dominant	Increase	5th	12.45	18.07	94
Gatherer Richness	Decrease	95th	14.8	13.00	88
Scraper Richness	Decrease	95th	5.8	2	34
Clinger Richness	Decrease	95th	9.8	9	92
			Final index value for this site:		**72**

Site R12

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	324	88
Taxa Richness	Decrease	95th	36	31	86
EPT Richness	Decrease	95th	17.8	19	100
Trichop Richness	Decrease	95th	7.4	7	95
Chiro Richness	Decrease	95th	11.2	7	63
% EPT	Decrease	95th	80.79	77.47	96
% Coleoptera	Decrease	95th	9.26	6.79	73
% Chironomidae	Increase	5th	6.55	10	96
Intolerant Richness	Decrease	95th	5.4	6	100
% Tolerant	Increase	5th	4.04	6.79	97
% Dominant	Increase	5th	12.45	11.42	100
Gatherer Richness	Decrease	95th	14.8	8.00	54
Scraper Richness	Decrease	95th	5.8	5	86
Clinger Richness	Decrease	95th	9.8	7	71
			Final index value for this site:		**86**

Site R13

Metric	Response to Impairment	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Abundance	Decrease	95th	368	350	95
Taxa Richness	Decrease	95th	36	36	100
EPT Richness	Decrease	95th	17.8	15	84
Trichop Richness	Decrease	95th	7.4	7	95
Chiro Richness	Decrease	95th	11.2	9	80
% EPT	Decrease	95th	80.79	48.57	60
% Coleoptera	Decrease	95th	9.26	4.00	43
% Chironomidae	Increase	5th	6.55	16	90
Intolerant Richness	Decrease	95th	5.4	4	74
% Tolerant	Increase	5th	4.04	30.57	72
% Dominant	Increase	5th	12.45	13.14	99
Gatherer Richness	Decrease	95th	14.8	14.00	95
Scraper Richness	Decrease	95th	5.8	4	69
Clinger Richness	Decrease	95th	9.8	11	100
			Final index value for this site:		**83**

Appendix O.
Terms and Definitions of the Physical Habitat Measurements

Terms and Definitions of the Physical Habitat Measurements

Definitions and measurements procedures for site variables (adapted from Wolman 1954; Hughes and Omernik 1981; Platts etal. 1983; Schumm et al. 1984, Robison and Beschta 1990; Gordon et al. 1992; Simonson et al. 1994, Harrelson et al. 1994, and Rosgen 1996).

Transect – A line that extends from the left bank to the right bank, perpendicular to stream flow.

Channel bank (stream bank) – The sides of the channel (or stream) that typically restrict lateral movement of water and sediment.

Channel bottom (stream bed) – The bottom portion of the channel (or stream) that typically does not restrict lateral movement of sediment and water.

Bankfull – That point on the channel bank where flows begin to crest that bank and move onto the floodplain.

Bank top – Often the same point as bankfull except in streams that are incised.

Incised – Describes channels or streams with bottoms that have or are in the process of downcutting into the landscape. High, steep, eroding banks are often associated with incised streams.

<u>Channel Morphometry</u>

Stream width (m) - Horizontal distance along transect, measured perpendicular to stream flow from left edge of water to right edge of water at existing water surface, to nearest 0.1 m.

Stream depth (m) - Vertical distance from existing water surface to channel bottom; measured at three equally spaced points along transect, to nearest 0.1 m.

Channel bottom depth (m) - Horizontal distance along transects, measured perpendicular to stream flow, measured as that section classified as stream bed not stream bank, to the nearest 0.1 m.

Bankfull width (m) - Horizontal distance along transects, measured perpendicular to stream flow, from top of low bank to a point of equal height on opposite bank, to nearest 0.1m. See Harrelson et al. (1994) for useful indicators of bankfull.

Bankfull depth (m) - Vertical distance from the plane of bankfull with to the channel bottom or bank, measured at a number of equally spaced points along the transect to adequately describe mean bankfull depth and cross-section, to the nearest 0.1 m.

Width:depth ratio - An index of cross-sectional shape, where both width and depth are measured at the bankfull level, unitless.

Bank height (m) - Vertical distance along transect from edge of channel bottom to level land on top of bank, measured to the nearest 0.1 m. Does not refer to bankfull height.
Stream bottom slope (%) - The amount of vertical drop per unit of horizontal distance along the channel bottom, measured with surveyor's level.

Stream surface slope (%) - The amount of vertical drop per unit of horizontal distance along the water surface, measured with surveyor's level.

Bed and Bank Material

It is very important to distinguish between clay and silt. Although both are composed of very fine particles, their properties are quite different. For example, clay can be very resistant to erosion, where particles of silt can be easily eroded. These properties can play a strong role in channel morphometry.

Channel bed substrate - Composition of bed material classified into size categories similar to Wolman's pebble count. A substrate particle is selected off the bed surface (except for fine substrates) at 8 equal distances along each transect in the channel and placed into one of the following categories:

Detritus (organic matter)
Clay (< 0.004 mm; inorganic matter; retains shape when compressed)
Silt (0.004-0.062 mm; inorganic matter does not retain shape when compressed)
Sand (0.062-2 mm)
Very Fine Gravel (2-4 mm)
Fine Gravel (4-8 mm)
Medium Gravel (8-16 mm)
Coarse Gravel (16-32 mm)
V. Coarse Gravel (32-64 mm)
Cobble (64-128 mm)
Large Cobble (128-256 mm)
Boulder (256-512 mm)
Large Boulder (>512 mm)

Streambed substrate - If the channel is not completely inundated, then this is the composition of bed material with the wetted channel classified in to size categories similar to Wolman's Pebble count. A substrate particle is selected off the inundated bed surface at eight equal distances along each transect in the stream and placed into one of the categories listed above.

Bank substrate - Composition of bank material classified into size categories similar to Wolman's Pebble Count.

Streambank and Riparian Characteristics

Streambank length - the linear distance along the transect from the junction of the stream bed and the stream bank to the top of the bank, measured to the nearest 0.1 m.

Streambank vegetation - A measurement of bank resistance to erosion due to vegetation, measured as the linear distance along the streambank length, which is vegetated by perennial herbaceous plants (grasses, forbs and aquatic species), shrubs or trees.

Streambank erosion - A measurement of bank instability along the transect line measured as the linear distance of exposed and eroded bank soils having very little to no structural support from vegetation during high flows. This does not include area of deposition where soils can be bare.

Streambank deposition - The Stream bank length that is neither vegetated not eroded.

Streambank slope (degree) - The angle formed by the downward slope of the stream bank and the horizontal stream bottom.

Riparian buffer with (m) - The condition of the land contour on the horizontal distance along the transect line from the stream's edge out 10 m. If the land is completely disturbed, then the riparian buffer is 0. If the land is completely undisturbed, then the buffer width is recorded as >10m. It may be appropriate to measure or approximate buffer widths beyond 10 m. Buffer widths <10 m should be measured to the nearest 1 m.

Riparian land use - The land use on the bank contour over the horizontal distance along the transect line from the stream's edge out 10 m. Land use classes are adapted from Simonson et al. (1994).

Vegetation use by animals - The condition of the vegetation by any land use (but primarily grazing and row cropping) on the transect line over the contour of the bank from the stream's edge out 10 m. Rating procedures are described by Platts et al. (1983).

Streamflow Characteristics

Streamflow (Q, cms) - The volume of water moving past a given stream cross section per unit of time.

Physical Fish Cover

Overhanging vegetation - If present, the bankside, banktop, and non-inundated vegetation that currently overhangs the water surface. Measured as the horizontal distance along the transect line from the water's edge to the furthest point over the water surface that the vegetation protrudes, to the nearest 0.1 m.

Undercut bank - If present, the horizontal distance along the transect line from the furthest point of bank protrusion and the furthest undercut of the bank, to the nearest 0.1 m.

Instream vegetation - If present the inundated macrophytic vegetation (submergent or emergent) within the stream channel. Measured as the total horizontal distance along the transect that has instream vegetation present as described, to the nearest 0.1 m.

Large woody debris (LWD), occurrence of - Generally, LWD are pieces of wood that are minimally 10 cm in diameter and 3 m long that occur within the bankfull channel providing potential cover for organisms. Measured along the transect and within one mean stream width separately as the number of pieces within the stream different zones.

Large woody debris (LWD), volume and orientation - Volume (cubic meters) of those same pieces within four zones calculated by measuring length and diameter of each piece of LWD. Orientation is recorded as the degrees to which the woody debris is predominately orientated with respect to the channel. Woody debris orientated completely upstream (i.e., root wad on downstream end) would be recorded as 180 while that orientated perpendicular to the channel would be recorded as 90, and that orientated completely downstream (i.e., root wad on upstream end) would be recorded as 0. See Robison and Beshta (1990).

Dominant habitat type along the transect is designated as pool, riffle, or run.

Stream bank and riparian features include several variables. A certain amount of ambiguity will occur when attempting to identify features used as endpoints for measuring this suite of linear features. One ambiguity is the breakpoint between the channel bank and channel bottom. Measurements related to stream bank length, bank angle, and bank height will be affected by location of this point. Another ambiguity is the demarcation between the vegetated and non-vegetated portions of the channel bank. The vegetated portion contributes a root structure that holds bank soil together.

Riparian-related cover types include five linear cover measurements that depend on the type and health of riparian vegetation: overhanging vegetation, undercut bank, submergent macrophytes, emergent macrophytes and large woody debris. When a piece of LWD or log jam is encountered, data entries include: transect space, log jam number (if applicable), LWD piece number, zone, meander location, habitat association, orientation (angle), and volume measurements (length and diameter). Transect space is simply the section between two consecutive transects. Zone, meander location, and habitat association are described on the data sheet. Volume measurements are the length and diameter of each piece of LWD. A graduated pole is more useful than a tape measure. One diameter measurement is made at the mid-section of the debris.

Bed and bank substrate data collection procedures follow the Wolman “pebble count” method. Along the transect, the bed is visually divided into eight cells using the tape measure as a guide. Within each cell, a crew member reaches to the bottom of the stream with one finger extended and eyes averted. The first piece of substrate touched is lifted to the surface. The substrate size is measured and the class size recorded. This method provides a way to objectively classify substrates in clear streams and is a necessity in turbid streams where visual estimates are not possible. Also, more than 100 substrates points can be combined from all transects, categorized and analyzed according to common fluvial methods or user needs.

Transect point data are measurements associated with a series of points lined up on an imaginary from left bank to the right bank. Each point has a location code, which identifies the channel feature at the point, and station number which is the point's horizontal distance from the left bank along the transect. Transect point data aid characterization of channel morphology, and are used to calculate the width if the stream surface, the channel bottom, and the width at bankfull. Point measurements include depth measurements. Depth measurements are used in conjunction with bankfull width to calculate width:depth ratios. Depth measurements and velocities are taken at three points in the stream (1/4, 1/2, and 3/4 of the distance across the stream surface) to characterize the physical conditions of the stream habitat at the time of sampling.

Discharge.—Discharge data is collected at a single transect or other stream cross-section where flows are uniform. The velocity-area method described in Gordon et al. (1992) is used.

Water Surface Slope (%) —Using a surveying level and tripod, or other method, the drop in water surface slope from transect one to transect 13 is measured and divided by the horizontal stream distance.

Water Quality.—Water quality data include easily measured parameters that are basic to a minimal assessment of the suitability of the site to fishes. Parameters are listed in Table 1.

Reach Classification.—For each reach, stream type (Rosgen 1996) and stage of channel evolution (Schumm et al. 1984) characterized level of stability and potential channel sources of sediment through bed and bank erosion.

Appendix P.
Field Data Sheets

On Site Description Data

Project Site ID:________________ Stream Name:

m/d/yr_____________

T______, R_____, ______1/4 of Sec______

GPS coordinates (utm): Transect 1,
Northing___________________________Easting_________________________

Downstream Transect,
Northing___________________________Easting_________________________

Investigators:____
____

Rosgen Classification (field level evaluation):____

Habitats Available number of each	Pool______ Run______ Riffle______ Other (describe) ________________________ Lengths of Riffle(s):_______, _______, _______, _______, _______. Total=________

Preliminary Mean Stream Width	
Width Number	Width (0.1 m)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Sum	
PMSW	

Transect Spacing:_______________

Water Quality

Parameter	Reading
Time (2400)	
Water Temperature (^oC)	
Air Temperature (^oC)	
Turbidity (NTU)	
Secchi (cm)	
Dissolved Oxygen (mg/L)	
Specific Conductance (uS/cm)	
Conductivity (uS/cm)	

Visual Observations:

Odor - yes no

Septic - yes no

Deadfish - yes no

Surface Film - yes no

Color:______________________________

Reach Length:

____

Weather Conditions:

Current	Past 24 h	
9	9	Clear/sunny
9	9	Partly cloudy
9	9	Intermittent showers
9	9	Steady rain
9	9	Heavy rain

Ice Cover - yes no

Map, Slope Measurements, and Photo-documentation Data

Project Site ID:_______________ Stream Name:
m/d/yr:____________

Water Surface Slope Measurements for Reach						
Transect #	Height of Inst. (cm)	Rod Reading from water surface (cm)	Elevation Difference (0.01 m)	Horizontal Distance (reach length above)	Slope (m/m)	Slope (%)

Draw a map of the site with location of most upstream and most downstream transects. Include locations of photographic points, direction of photograph, and frame number.

Bed Substrate Composition

Project Site ID:________________ Stream Name:
m/d/yr:_____________

Organic Substrates			
	Description	Tally	Number
Detritus	sticks, wood, coarse plant material (CPOM)		
Muck-Mud	black, very fine organic (FPOM)		
Inorganic Substrates			
	Diameter	Tally	Number
Clay	<0.004 (slick)		
Silt	0.004-0.062		
Sand	0.062-2 (gritty)		
Very Fine Gravel	>2-4		
Fine Gravel	>4-8		
Medium Gravel	>8-16		
Coarse Gravel	>16-32		
Very Coarse Gravel	>32-64		
Cobble	>64-128		
Large Cobble	>128-256		
Boulder	>256-512		
Large Boulder	>512		
		Total Number:	

Transect Data

Project Site ID:___________ Stream Name:
m/d/yr:___________________ Transect Number _______of ________ Habitat Type Along Transect (circle one): pool riffle run

Streambank and Riparian Features	Left Bank	Right Bank
Bank Substrate (dominant)		
Bank Slumpage (present, p or absent, a)		
Bank Height (0.1 m)		
Bankfull Height (0.1)		
Bank Angle (degrees)		
Streambank length (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Riparian landuse (circle one)	cropland, woodland/forested, pasture/rangeland, barnyard, prairie, developed, wetland, other-specify, shrub	cropland, woodland/forested, pasture/rangeland, barnyard, prairie, developed, wetland, other-specify, shrub
Animal Vegetation Use (circle one)	none, moderate, low, high	none, moderate, low, high
Riparian Vegetation Type (Dominant)	sedge/rush, willows, cottonwoods, silver maple, grass/forb, shrubs, green ash, other__________	sedge/rush, willows, cottonwoods, silver maple, grass/forb, shrubs, green ash, other__________
Riparian Age Class(es) of Trees, if present	seedling/sprout, decadent, young/sapling, dead, mature	seedling/sprout, decadent, young/sapling, dead, mature
Riparian Buffer Width (m)		
Overhanging Vegetation (0.1 m)		
Undercut Bank (0.1 m)		
Submergent Macrophytes (0.1 m)		
Emergent Macrophytes (0.1 m)		

Transect Data and Depth Velocity Data
(record units under the heading for each column)

Location Code	Station	Bankfull Depth	Water Depth	Velocity
LTB				
LBF				
LEW				
LCB				
STR (@1/4)				
STR (@1/2)				
STR (@3/4)				
RCB				
REW				
RBF				
RTB				

Location Codes:

- LTB left top bank
- RTB right top bank
- LBF left bankfull
- RBF right bankfull
- LCB left channel bottom
- RCB right channel bottom
- LEW left edge water
- REW right edge water
- STR stream

Bank top width (RTB-LTB) =____________

Bankfull width (RBF-LBF)=____________

Channel Bottom Width (RCB-LCB)=____________

Stream Width (REW-LEW)=____________

Average Bank Full Depth = ______________

Seine Fish Data

Project Site ID:_______Stream Name:_________________________m/d/yr:___________Page ________of______

Method of Collection	9 Upstream 9 Downstream 9 Cross-stream 9 Kick Bag attached? Yes No Mesh Size_______ Block nets used? Yes No
Habitat Sample ID #	
Habitat(s) Sampled for ID # listed above	9 Pool 9 Run 9 Riffle 9 Composite (entire reach) 9 Other (describe)____
Transect spacing for above ID #	Starting Transect____________ Ending Transect____________
Pass #	____________of______________

Fish Data

Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies	Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies

Parasites & Anomalies Code: D= deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=blackspot, EM=emaciated, O=other.

Project Site ID _______ Stream Name:_____________________________m/d/yr:
Page_____of_______

Habitat Sample ID #______________________Pass #:__________of __________

Fish Data									
Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies	Species Code	Bulk #	Length (mm)	Bulk weight (g)	Parasites &Anomalies

Parasites & Anomalies Code: D= deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=blackspot, EM=emaciated, O=other.

Large Woody Debris Data

Project Site ID:__________ Stream Name:
m/d/yr:______________ Page ____of ___

Transect Spacing	Log Jam Number	LWD Number	Zone	Meander Location	Habitat Association	Angle	Length	Diameter

Zone: B=bank, C=mid-channel
Meander Location: IM=inside meander, OM=outside meander, CO=crossover, SS=straight section
Habitat Association: PL=pool, RF=riffle, RN=run

Discharge (record units under the heading for each column)

Project Site ID:_______________ Stream Name:
m/d/yr:_____________

Staff Gauge Reading:___________________

Number	Cell Spacing	Station	Cell Width (W)	Cell Depth (D)	Velocity (V)	Cell Discharge (W x D x V)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
					Total Discharge = Sum=	

Appendix P

Macroinvertebrate Rock Basket Information

Project Site ID:__________ Site Location:______________________________

Canopy Cover (circle one): 0-25% 26-50% 51-75% 76-100%

Rock Basket Placement Conditions

Date:_______________ Time:_________ Placed By:________________________

Number of Rock Baskets Placed:__________ Design (circle one): Cone Flat

Basket Number	Water Depth	Water Velocity	Habitat Type	Comments
1				
2				
3				
4				
5				

Interim Conditions

Date:_______________ Time:_________

Basket Number	Water Depth	Water Velocity	Habitat Type	Comments
1				
2				
3				
4				
5				

Rock Basket Retrieval Conditions

Date:_______________ Time:_________ Recovered By:____________________

Number of Rock Baskets Recovered:________ Colonization Days:_______________

Litter Packs(circle one): Absent/Rare Common Abundant

Basket Number	Water Depth	Water Velocity	Habitat Type	Comments
1				
2				
3				
4				
5				

(over)

Macroinvertebrate Rock Basket Information

Project ______________________________

Project Site ID _______________________

Site Name ___________________________

Date of Placement ____________________	Date of Retrieval ___________________
DO __________________	DO ________________________
Water Temp ____________________	Water Temp _________________________
Conductivity ____________________	Conductivity _________________________
pH ___________________	pH ____________________
Turbidity __________________	Turbidity ___________________

Basket Location Map:

Appendix Q.
Score Sheets for the Physical Habitat Metrics

Score Sheets for Physical Habitat Metrics – By Site

Site T01

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	10	100
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**68**

Site T02

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	7.5	75
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	0	0
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	7.5	100
Animal Vegetation Use	95th	10	10	100
		Final index value for this site:		**52**

Site T03

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	10	100
Bed Composition	95th	18	12	67
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	20	100
Overhanging Vegetation	95th	7.5	10	100
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**80**

Site T04

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	16	89
Measure of Incision	95th	10	0	0
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	100
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**70**

Site T05

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	2.5	33
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**63**

Site T06

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	7.5	75
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	18	12	67
Measure of Incision	95th	10	7.5	75
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**58**

Site T07

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	18	16	89
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	2.5	33
Animal Vegetation Use	95th	10	2.5	25
		Final index value for this site:		**59**

Site T08

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	7.5	75
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	10	100
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	5	25
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	2.5	25
		Final index value for this site:		**46**

Site T09

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	12	67
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**52**

Site T10

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	10	100
Bed Composition	95th	18	0	0
Measure of Incision	95th	10	10	100
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**59**

Site T11

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	12	67
Measure of Incision	95th	10	0	0
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	5	67
Animal Vegetation Use	95th	10	2.5	25
		Final index value for this site:		**54**

Site T13

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	10	100
Bed Composition	95th	18	12	67
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	2.5	33
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**63**

Site T14

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	5	67
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**70**

Site T15

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	4	22
Measure of Incision	95th	10	10	100
Bank Stability	95th	20	20	100
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**50**

Site T16

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	2.5	25
CV of Velocity	95th	10	10	100
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	20	100
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**62**

Site T17

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	7.5	75
Bank Stability	95th	20	5	25
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**46**

Site T18

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	10	100
Bank Stability	95th	20	5	25
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	2.5	25
		Final index value for this site:		**40**

Site T19

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	0	0
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**31**

Site T20

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	18	16	89
Measure of Incision	95th	10	7.5	75
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**67**

Site T21

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	16	89
Measure of Incision	95th	10	0	0
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	10	100
		Final index value for this site:		**61**

Site T22

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	0	0
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	2.5	33
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**39**

Site T23

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	7.5	75
Bed Composition	95th	18	20	100
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	10	100
		Final index value for this site:		**75**

Site T25

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	7.5	100
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**65**

Site T26

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	4	22
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**43**

Site T27

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	0	0
Bank Stability	95th	20	5	25
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**46**

Site T28

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	10	100
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	10	50
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**56**

Site T29

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	0	0
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	16	89
Measure of Incision	95th	10	7.5	75
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	7.5	100
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**67**

Site T30

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	7.5	75
CV of Velocity	95th	10	5	50
Bed Composition	95th	18	20	100
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	20	100
Overhanging Vegetation	95th	7.5	2.5	33
Animal Vegetation Use	95th	10	2.5	25
		Final index value for this site:		**64**

Site T31

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	2.5	25
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	8	44
Measure of Incision	95th	10	2.5	25
Bank Stability	95th	20	15	75
Overhanging Vegetation	95th	7.5	2.5	33
Animal Vegetation Use	95th	10	7.5	75
		Final index value for this site:		**50**

Site T32

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	2.5	25
CV of Velocity	95th	10	0	0
Bed Composition	95th	18	4	22
Measure of Incision	95th	10	0	0
Bank Stability	95th	20	5	25
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	10	100
		Final index value for this site:		**34**

Site T33

Metric	Percentile for "best" value	Standard (best value)	Measured metric value	Standardized Metric score
Channel Flow Status	95th	10	10	100
Physical Complexity	95th	10	5	50
CV of Velocity	95th	10	2.5	25
Bed Composition	95th	18	4	22
Measure of Incision	95th	10	5	50
Bank Stability	95th	20	0	0
Overhanging Vegetation	95th	7.5	0	0
Animal Vegetation Use	95th	10	5	50
		Final index value for this site:		**37**

Appendix R.
WRI Lab Memo

To: East Dakota Water Development District project staff 1/17/03

From: David German

Re: QA/QC problems with the Kjeldahl Unit

A malfunction of the Kjeldahl unit in the Water Resources Institute's Water Quality Laboratory (WQL) was identified in October 2002. The decision has been made to replace the unit. A call for bids is going out next week. The new unit should be on-line by mid-March 2003.

The Kingsbury Lakes project staff first reported hits on blanks they had submitted to the lab in 2001. Water Quality Lab staff ran additional blanks on the instrument to check for errors at that time. Results were good and the hits were assumed to be due to sample preparation and handling. Source water, acid preservative, and bottles are all possible sources of nitrogen in blanks.

For example, source water was a problem for East Dakota Water Development District (EDWDD) blanks submitted in July and August 2002, which had small but detectable concentrations of dissolved solids. The reverse osmosis (R.O.) unit in the WQL had reduced efficiency during this period until the membrane was replaced. The best source water for blanks is water produced by the Nanopure system. This unit produces small quantities of very high quality water, which should be used for all blanks and preparation of known additions to blanks. R.O. water is adequate for washing and rinsing but may contain small amounts of nitrate and other constituents.

It is my understanding that the Kingsbury Lakes project staff took a series of steps to identify the problem causing detections in the blanks. In September 2002 project leaders became convinced the problem was in the WQL rather than in sample preparation. A series of test runs were completed to diagnose the problem. The results of those test runs are included in Tables 1 and 2. The results of these tests indicated a malfunction of the Kendal unit.

Table 1 includes the results of samples mostly submitted by the Kingsbury Lakes project. Results of analysis from blanks and knowns ran by the WQL are presented in Table 2. I met with the Kingsbury Lakes project staff to discuss a plan to determine the source of the malfunction. Two lab blanks were analyzed on 9-23-02 (Table 2). A significant hit (.424 ppm) was observed on burner #5. A set of samples submitted by Kingsbury Lakes project staff as actual lake samples were also analyzed on 9-24-02 and 9-25-02. Hits were observed on burners 5 and 6 (Table 1) but results were inconsistent. For example, a hit was observed on burner 5 on 9-25-02, but not on 9-24-02 (Table 1).

The intermittent nature of the problem was evident in the QA/QC samples submitted by the Kingsbury Lake project earlier in the year also (Table 1). For example, a hit was observed on burner 3 on 7-30-02 but not on 7-29-02.

Analysis of the QA/QC data in Table 1 indicated intermittent problems with burners 3, 5, 6, and 11. Most of the blanks analyzed in 2002 for both the Kingsbury Lakes project and the EDWDD were analyzed on these four burners.

Following the set of blanks submitted as samples by the Kingsbury Lakes project staff a series of test runs were conducted by the WQL. The additional blanks were analyzed by the WQL to determine if a pattern could be established that would allow for correction of the data. The results are presented in Table 2. Burners 5 and 6 appear to be the most likely to produce hits, although not consistently. Burner 3 was also suspect based on hits in July (Table 1) but was not included in the test phase because it went out of service on September 17th and the parts needed for repair were out of stock.

The lack of consistency of hits on a particular burner may be due to the amount of ammonia in the air in the lab. According to the manufacturer, the distillation unit consists of a stacked apparatus with seals between the parts. A failure in these seals may allow distillation of ammonia from the air in the lab into a blank sample. This may account for the lack of hits in the ammonia analysis (the first distillation of the day) when compared to the organic ammonia distillation (the second distillation of the day). More ammonia in the air around the instrument in the afternoon is available to leak into the distillation unit on the second distillation. This may also explain why lower hits were observed when full sets of blanks were run (Table 2).

After reviewing the results from the series of runs using lab blanks I still had some questions about how the problem affects actual sample values. Blanks seem to have an error of approximately .4 ppm increase in concentration when run with actual samples. The concentration seems to be less when a full set of blanks is run even on #6 (Table 2). Over the Christmas break I started to wonder if having samples on the other burners could cause a blank to cause higher blanks so I talked to Shirley about doing a blank and a dup in a sample run. On 12/31/02 she ran a dup on #4 (3.13 ppm) and #6 (3.21 ppm) and a blank on #5 (.03ppm) (Table 1). These results show a slight increase in concentration on 5 & 6 but the magnitude is less than we see in blanks submitted by both projects.

A full set of samples of known concentration were analyzed on 1-2-03. The knowns were handled exactly like a set of samples. Results were acceptable (table 2). The actual value was 1.13 ppm and the test results ranged from 1.03 to 1.15 from burners 4 through 11.

Blanks were also included with runs of samples on 1-6-03, 1-7-03, and 1-8-03 on burners 5 and 6. Hits were observed but were an order of magnitude below what had been observed in some blanks in earlier QA/QC runs (Table 2) and in project blanks. It seems difficult to reproduce the concentrations observed in blanks submitted by the project staff in test runs of lab blanks that have been analyzed so far by the WQL. This has been troubling me for a while now and has caused me to wonder what is missing. As I studied the most recent data I realized we had not completed a test run with actual samples and blanks combined that included both the distillation for ammonia and organic nitrogen.

When a separate result for ammonia is not required, a digestion step is followed by a distillation step (the first of the day) which produces a result for TKN. Analyses that were conducted this way are labeled TKN only in the comments column (Table 2). It seems that fewer problems were observed when the separate distillation to determine ammonia was not done prior to the digestion of the organic nitrogen. A test run using actual samples and blanks combined that included both the distillation for ammonia and organic nitrogen may be helpful to recreate the type of hits observed in the project blanks.

The question is “can any of this information help determine correction factors for the data produced during the time the instrument exhibited intermittent problems?”

1. The problem is probably caused by leaky seals in the distillation apparatus which allows ammonia from the air to be condensed into the sample so quantity in the blank may be a function of the amount in the lab air.

2. The problems with blanks seemed to occur most often at the beginning of runs (burners # 3,5 or 6) where the blanks were often placed but there were exceptions.

3. A correction factor is unlikely to increase the accuracy of the data because of the intermittent nature of the problem and the difficulty of determining the burner position of a given sample.

4. A higher than normal error rate in the data occurred for samples submitted in 2001 and 2002.

I am not confident enough about the specific location of the problem on the instrument to identify correction factors that could be applied to specific samples. I think the best course of action at this point is to report the data as is, with the qualification that an error of approximately .4 ppm may be present in some TKN results due to instrument malfunctions.

Appendix S.
QA/QC – WQ Duplicates and Blanks

Stream	Time	Sample	Depth	Date	Site	Lab#	Water Temp C	Air Temp C	DO mg/L	pH su	cfu per 100mL	TSS mg/L	Total Solids mg/L	TDS mg/L	NO2NO3 mg/L	NH3N mg/L	OrgNtr mg/L	TKN mg/L	Tot PO4 mg/L	Tot Dis PO4 mg/L
Spring Creek	1100	Grab	Surface	07/27/99	T11	99-6010	24.1	31	7	8	860	36	652	616	2.39	0.12	1.04	1.16	0.290	0.235
Duplicate		Grab	Surface			99-6018					100	34	520	486	2.43	0.10	0.88	0.98	0.292	0.231
Absolute Difference											760	2	132	130	0.03	0.02	0.16	0.18	0.002	0.004
Percent Difference											88	6	20	21	1.44	15.25	15.52	15.49	0.617	1.705
Six Mile Creek-Lower	1130	Grab	Surface	08/09/99	T05	99-6025	22.6	27	5	8.4	1800	44	616	572	0.14	0.22	1.19	1.40	0.196	0.106
Duplicate		Grab	Surface			99-6022					1500	48	736	784	0.15	0.18	1.48	1.66	0.202	0.111
Absolute Difference											300	4	120	212	0.01	0.03	0.29	0.26	0.006	0.005
Percent Difference											17	8	16	27	7.95	15.81	19.84	15.69	3.017	4.513
BSR-Trent	1430	Grab	Surface	08/10/99	R07	99-6037	26.8	32.5	9.4	8.8	50	152	976	824	0.06	0.09	2.54	2.63	0.353	0.049
Duplicate		Grab	Surface			99-6040					150	155	1019	864	0.06	0.14	2.47	2.61	0.350	0.044
Absolute Difference											100	3	43	40	0.00	0.05	0.08	0.02	0.003	0.005
Percent Difference											67	2	4	5	5.08	37.14	2.99	0.91	0.766	9.877
Spring Creek	1100	Grab	Surface	08/10/99	T11	99-6030	24.1	30	8.1	8.2	1300	19	599	580	2.79	0.11	0.71	0.82	0.150	0.121
Duplicate		Grab	Surface			99-6021					870	17	601	584	2.74	0.10	1.06	1.15	0.151	0.127
Absolute Difference											430	2	2	4	0.05	0.01	0.34	0.33	0.002	0.006
Percent Difference											33	11	0	1	1.94	10.81	32.51	28.68	0.993	4.664
BSR - Flandreau	1330	Grab	Surface	09/13/99	R05	99-6057	14.8	16	5.8	8.8	50	90	822	732	0.27	0.04	2.35	2.39	0.328	0.067
Duplicate		Grab	Surface			99-6061					60	96	814	718	0.27	0.04	2.39	2.42	0.330	0.077
Absolute Difference											10	6	8	14	0.00	0.00	0.03	0.03	0.003	0.010
Percent Difference											17	6	1	2	0.73	0.00	1.38	1.36	0.787	12.647
Medary Creek-Lower	1130	Grab	Surface	09/13/99	T09	99-6051	12.9	12	8.9	8.4	530	20	464	444	1.36	0.06	0.71	0.77	0.063	0.022
Duplicate		Grab	Surface			99-6044					650	24	576	552	1.33	0.05	0.65	0.70	0.069	0.023
Absolute Difference											120	4	112	108	0.03	0.01	0.06	0.07	0.006	0.000
Percent Difference											18	17	19	20	2.35	23.73	8.03	9.23	8.934	1.762
Six Mile Creek-Lower	1100	Grab	Surface	10/12/99	T05	99-6087	13.3	17	8	8.2	650	14	562	548	0.10	0.05	0.62	0.67	0.154	0.121
Duplicate		Grab	Surface			99-6084					610	16	612	596	0.08	0.05	0.57	0.62	0.161	0.143
Absolute Difference											40	2	50	48	0.01	0.00	0.04	0.04	0.007	0.022
Percent Difference											6	13	8	8	13.40	7.55	7.14	6.17	4.342	15.067
BSR-Bkgs USGS Guage	1415	Grab	Surface	10/12/99	R04	99-6096	13.1	21	11.7	8.7	20	48	700	652	0.35	0.03	1.93	1.96	0.255	0.019
Duplicate		Grab	Surface			99-6101					10	49	739	690	0.36	0.01	1.86	1.88	0.252	0.023
Absolute Difference											10	1	39	38	0.01	0.02	0.06	0.08	0.003	0.004
Percent Difference											50	2	5	6	1.96	64.52	3.32	4.29	1.060	17.094

BSR at USGS Brookings	1100	Grab	Surface	03/13/00	R04	00-6010	1.4	8	13.3	8.5	1	33	695	662	1.23	0.12	1.45	1.57	0.442	0.291
Duplicate		Grab	Surface			00-6011					1	31	783	752	1.23	0.14	1.18	1.32	0.437	0.302
Absolute Difference											0	2	88	90	0.01	0.01	0.27	0.25	0.005	0.012
Percent Difference											0	6	11	12	0.49	10.29	18.40	16.07	1.064	3.836
BSR at USGS Brookings	1000	Grab	Surface	04/10/00	R04	00-6023	7.6	6	10.1	8.6	10	70	822	752	0.83	0.05	1.30	1.35	0.296	0.112
Duplicate		Grab	Surface			00-6024					20	70	926	856	0.83	0.05	1.38	1.43	0.295	0.119
Absolute Difference											10	0	104	104	0.00	0.01	0.08	0.08	0.001	0.007
Percent Difference											50	0	11	12	0.24	13.46	5.45	5.74	0.271	5.640
Jack Moore Creek	1130	Grab	Surface	04/11/00	T13	00-6040	6.5	5	10.4	8.2	360	2	894	892	0.11	0.03	1.34	1.37	0.154	0.110
Duplicate		Grab	Surface			00-6041					430	3	903	900	0.10	0.02	1.36	1.39	0.154	0.113
Absolute Difference											70	1	9	8	0.00	0.01	0.02	0.01	0.001	0.003
Percent Difference											16	33	1	1	2.83	25.81	1.47	0.79	0.389	2.473
BSR at Sinai Road	925	Grab	Surface	05/09/00	R02	00-6059	13.1	23	8.1	8.3	300	126	842	716	0.03	0.10	2.35	2.46	0.391	0.022
Duplicate		Grab	Surface			00-6060					400	135	767	632	0.31	0.08	2.10	2.18	0.388	0.032
Absolute Difference											100	9	75	84	0.28	0.03	0.26	0.28	0.003	0.010
Percent Difference											25	7	9	12	89.03	25.00	10.92	11.51	0.743	31.875
BSR at Trent	1145	Grab	Surface	05/09/00	R07	00-6064	15.6	24	9.7	8.4	4000	75	687	612	0.24	0.06	1.63	1.69	0.269	0.028
Duplicate		Grab	Surface			00-6065					6700	75	695	620	0.24	0.02	1.72	1.75	0.246	0.027
Absolute Difference											2700	0	8	8	0.01	0.03	0.09	0.06	0.023	0.000
Percent Difference											40	0	1	1	2.48	60.71	5.28	3.27	8.612	0.725
Bachelor Creek	1545	Grab	Surface	05/16/00	T14	00-6082	19.6	26	13.2	8.3	1100	9	1413	1404	0.58	0.09	1.06	1.15	0.106	0.083
Duplicate		Grab	Surface			00-6084					1000	9	1393	1384	0.56	0.11	0.93	1.04	0.113	0.084
Absolute Difference											100	0	20	20	0.01	0.02	0.13	0.11	0.008	0.002
Percent Difference											9	0	1	1	2.26	16.07	11.93	9.39	6.637	2.133
BSR at Sinai Road	900	Grab	Surface	05/19/00	R02	00-6094	12.5	12	7.5	8.4	6800	195	615	420	0.55	0.19	1.93	2.12	0.594	0.191
Duplicate		Grab	Surface			00-6095					6100	206	667	461	0.57	0.14	2.09	2.23	0.602	0.207
Absolute Difference											700	11	52	41	0.03	0.05	0.16	0.10	0.008	0.016
Percent Difference											10	5	8	9	4.55	27.32	7.43	4.58	1.328	7.782
BSR at Trent	1300	Grab	Surface	05/19/00	R07	00-6104	14.4	23	8.2	8.2	17000	240	816	576	1.28	0.16	2.40	2.57	0.588	0.147
Duplicate		Grab	Surface			00-6105					15000	244	796	552	1.25	0.18	2.38	2.56	0.581	0.145
Absolute Difference											2000	4	20	24	0.03	0.02	0.02	0.01	0.006	0.002
Percent Difference											12	2	2	4	2.35	8.38	0.92	0.27	1.089	1.022

Lake Campbell Outlet	930	Grab	Surface	05/22/00	T10	00-6107	18.5	29	8.2	8.1	10	28	1696	1668	0.15	0.30	1.18	1.48	0.103	0.042
Duplicate		Grab	Surface			00-6106					10	20	1616	1596	0.17	0.28	1.46	1.73	0.093	0.042
Absolute Difference											0	8	80	72	0.02	0.02	0.28	0.25	0.010	0.000
Percent Difference											0	29	5	4	10.24	8.00	19.07	14.65	9.496	0.239
Jack Moore Creek	1445	Grab	Surface	05/31/00	T13	00-6114	20.3	26	6.4	8.0	19000	67	947	880	0.46	0.24	1.49	1.73	0.348	0.205
Duplicate		Grab	Surface			00-6115					10000	67	962	895	0.46	0.10	1.48	1.58	0.377	0.212
Absolute Difference											9000	0	15	15	0.01	0.13	0.02	0.15	0.029	0.007
Percent Difference											47	0	2	2	1.08	56.30	1.14	8.72	7.643	3.252
BSR at Trent	1100	Grab	Surface	06/02/00	R07	00-6123	16.9	21	7.3	7.8	300	270	754	484	0.76	0.20	1.95	2.15	0.608	0.132
Duplicate		Grab	Surface			00-6125					700	278	755	477	0.76	0.20	1.98	2.18	0.602	0.123
Absolute Difference											400	8	1	7	0.00	0.01	0.03	0.03	0.007	0.009
Percent Difference											57	3	0	1	0.39	2.99	1.41	1.56	1.134	7.029
Beaver Ck (upper)	1550	Grab	Surface	06/12/00	T32	00-6138	25.2	36	9.2	8.1	700	49	625	576	5.30	0.02	1.25	1.27	0.177	0.066
Duplicate		Grab	Surface			00-6140					900	54	588	534	5.24	0.04	1.23	1.27	0.177	0.068
Absolute Difference											200	5	37	42	0.06	0.02	0.02	0.01	0.000	0.002
Percent Difference											22	9	6	7	1.13	43.59	1.92	0.55	0.169	2.511
Bachelor Creek	1100	Grab	Surface	06/13/00	T14	00-6141	20.7	26	8.3	8.1	1000	13	1281	1268	0.36	0.06	1.31	1.37	0.069	0.031
Duplicate		Grab	Surface			00-6142					1500	10	1286	1276	0.32	0.03	0.93	0.96	0.071	0.030
Absolute Difference											500	3	5	8	0.04	0.03	0.38	0.40	0.003	0.002
Percent Difference											33	23	0	1	12.01	43.86	28.88	29.50	3.922	5.732
Deer Creek	1345	Grab	Surface	06/13/00	T06	00-6162	20.9	26	8.7	8.17	1300	23	643	620	0.06	0.05	0.61	0.66	0.045	0.022
Duplicate		Grab	Surface			00-6165					1200	17	653	636	0.05	0.05	0.62	0.66	0.047	0.044
Absolute Difference											100	6	10	16	0.00	0.01	0.01	0.00	0.002	0.022
Percent Difference											8	26	2	3	7.27	13.21	0.81	0.30	4.069	49.775
Slip-up Creek	1445	Grab	Surface	06/14/00	T25	00-6171	17.3	20	7.4	8.56	3200	33	585	552	5.73	0.12	1.45	1.57	0.166	0.070
Duplicate		Grab	Surface			00-6172					3000	34	574	540	5.79	0.13	1.34	1.47	0.149	0.070
Absolute Difference											200	1	11	12	0.05	0.01	0.11	0.10	0.017	0.000
Percent Difference											6	3	2	2	0.90	6.98	7.59	6.43	10.337	0.284
Medary Ck (lower)	1430	Grab	Surface	06/28/00	T09	00-6183	22.8	31	9.2	8.3	90	54	662	608	0.74	0.12	1.05	1.17	0.163	0.045
Duplicate		Grab	Surface			00-6186					60	51	655	604	0.74	0.13	1.07	1.20	0.155	0.059
Absolute Difference											30	3	7	4	0.00	0.02	0.01	0.03	0.008	0.014
Percent Difference											33	6	1	1	0.27	12.12	1.22	2.42	4.663	23.649
BSR at Hwy 77	1400	Grab	Surface	06/28/00	R03	00-6185	22.2	31	8.3	8.4	60	248	844	596	0.41	0.12	2.48	2.60	0.597	0.126

Duplicate		Grab	Surface			00-6188					90	262	886	624	0.40	0.10	2.48	2.57	0.583	0.087
Absolute Difference											30	14	42	28	0.01	0.03	0.00	0.03	0.015	0.039
Percent Difference											33	5	5	4	2.43	20.83	0.16	1.12	2.444	31.007
Split Rock Ck (lower)	1330	Grab	Surface	07/10/00	T31	00-6198	26.3	31	5.6	8.0	1000	182	438	256	0.89	0.20	2.38	2.58	0.668	0.210
Duplicate		Grab	Surface			00-6197					88000	210	470	260	0.91	0.20	2.48	2.69	0.715	0.216
Absolute Difference											87000	28	32	4	0.02	0.01	0.10	0.11	0.048	0.006
Percent Difference											99	13	7	2	2.09	3.45	4.15	4.10	6.655	2.866
BSR at Brandon	1400	Grab	Surface	07/11/00	R12	00-6209	28.3	30	8.9	7.9	2200	111	739	628	2.34	0.05	2.24	2.29	0.821	0.513
Duplicate		Grab	Surface			00-6211					2600	110	718	608	3.03	0.07	2.23	2.98	0.902	0.509
Absolute Difference											400	1	21	20	0.69	0.03	0.02	0.69	0.080	0.003
Percent Difference											15	1	3	3	22.91	35.71	0.71	23.19	8.928	0.624
BSR nr Gitchie Manitou	1300	Grab	Surface	07/11/00	R13	00-6208	26.5	33	6.2	7.2	4800	117	633	516	1.84	0.08	2.13	2.21	0.677	0.329
Duplicate		Grab	Surface			00-6214					3700	115	711	596	1.96	0.08	2.10	2.18	0.698	0.031
Absolute Difference											1100	2	78	80	0.12	0.00	0.03	0.03	0.022	0.298
Percent Difference											23	2	11	13	6.02	5.00	1.31	1.45	3.108	90.522
No Deer Ck (upper)	1000	Grab	Surface	07/12/00	T01	00-6226	22.3	27	3.4	8.1	1900	10	410	400	0.14	0.21	1.02	1.22	0.299	0.255
Duplicate		Grab	Surface			00-6227					1800	12	407	395	0.12	0.21	1.28	1.49	0.285	0.269
Absolute Difference											100	2	3	5	0.02	0.00	0.27	0.27	0.013	0.014
Percent Difference											5	17	1	1	13.33	0.48	20.89	17.93	4.421	5.097
Skunk Ck (upper)	1100	Grab	Surface	07/13/00	T18	00-6224	29	29	9.5	7.7	1600	151	1330	1179	0.07	0.08	3.45	3.52	0.385	0.049
Duplicate		Grab	Surface			00-6238					1700	138	1358	1220	0.05	0.13	3.58	3.71	0.440	0.064
Absolute Difference											100	13	28	41	0.02	0.05	0.13	0.19	0.056	0.015
Percent Difference											6	9	2	3	26.39	41.41	3.69	4.99	12.670	23.292
Colton Creek	1230	Grab	Surface	07/13/00	T19	00-6225	26.3	30	4	7.6	29000	784	1224	440	1.23	0.53	3.83	4.36	1.558	0.235
Duplicate		Grab	Surface			00-6239					14000	754	1310	556	1.26	0.50	4.38	4.88	1.500	0.266
Absolute Difference											15000	30	86	116	0.03	0.02	0.55	0.52	0.057	0.031
Percent Difference											52	4	7	21	2.38	4.55	12.47	10.69	3.666	11.743
W. Branch Skunk Ck	1330	Grab	Surface	07/13/00	T20	00-6241	28.5	31	4.2	7.1	2100	138	1099	961	2.15	0.41	2.29	2.70	0.454	0.173
Duplicate		Grab	Surface			00-6240					3600	138	1058	920	2.11	0.43	2.34	2.77	0.455	0.155
Absolute Difference											1500	0	41	41	0.04	0.02	0.05	0.07	0.000	0.018
Percent Difference											42	0	4	4	1.86	3.76	2.13	2.38	0.088	10.185
BSR nr Brookings	1000	Grab	Surface	07/14/00	R01	00-6245	25.5	31	5.2	8.0	300	314	886	572	0.12	0.10	3.35	3.45	0.648	0.047
Duplicate		Grab	Surface			00-6253					700	311	887	576	0.08	0.18	3.25	3.43	0.592	0.067
Absolute Difference											400	3	1	4	0.03	0.09	0.10	0.01	0.056	0.021

Percent Difference											57	1	0	1	29.57	47.22	2.87	0.32	8.616	30.861
BSR nr Flandreau	1215	Grab	Surface	07/14/00	R05	00-6249	27.4	32	5.9	7.9	200	147	715	568	0.28	0.16	2.39	2.55	0.436	0.102
Duplicate		Grab	Surface			00-6254					300	156	580	424	0.27	0.13	0.01	0.13	0.371	0.108
Absolute Difference											100	9	135	144	0.02	0.03	2.39	2.43	0.065	0.006
Percent Difference											33	6	19	25	5.69	20.99	99.79	94.99	14.869	5.540
Brant Lake Outlet	1230	Grab	Surface	08/14/00	T17	00-6264	31.1	32	9.5	8.7	4000	35	1107	1072	0.12	0.05	2.62	2.66	0.282	0.058
Duplicate		Grab	Surface			00-6259					4900	35	1095	1060	0.18	0.03	2.76	2.79	0.264	0.119
Absolute Difference											900	0	12	12	0.06	0.02	0.15	0.13	0.018	0.061
Percent Difference											18	0	1	1	35.56	34.78	5.35	4.72	6.246	51.010
Skunk Creek (lower)	1630	Grab	Surface	08/14/00	T23	00-6272	31	35	13.2	8.2	400	59	867	808	0.07	0.15	1.77	1.91	0.294	0.013
Duplicate		Grab	Surface			00-6273					150	58	726	668	0.06	0.11	1.92	2.02	0.316	0.019
Absolute Difference											250	1	141	140	0.02	0.04	0.15	0.11	0.022	0.006
Percent Difference											63	2	16	17	22.54	27.59	7.83	5.45	6.806	33.333
Six Mile Ck (middle)	945	Grab	Surface	08/15/00	T04	00-6275	23.5	22	5.1	7.8	1700	92	640	548	0.32	0.25	2.05	2.29	0.280	0.034
Duplicate		Grab	Surface			00-6276					1500	90	618	528	0.31	0.24	1.83	2.08	0.235	0.054
Absolute Difference											200	2	22	20	0.01	0.00	0.21	0.22	0.045	0.020
Percent Difference											12	2	3	4	2.81	0.81	10.45	9.42	16.000	36.754
Pipestone Ck (lower)	1020	Grab	Surface	08/16/00	T29	00-6286	18.8	20	9.3	8.1	310	29	529	500	0.12	0.07	1.47	1.54	0.513	0.131
Duplicate		Grab	Surface			00-6287					350	29	501	472	0.12	0.11	1.32	1.43	0.535	0.129
Absolute Difference											40	0	28	28	0.01	0.05	0.15	0.11	0.022	0.002
Percent Difference											11	0	5	6	5.65	40.54	10.34	6.97	4.039	1.679
BSR at Hwy 38A	1410	Grab	Surface	08/16/00	R09	00-6295	21.6	24	5.8	8.0	500	106	586	480	0.06	0.03	1.86	1.89	0.350	0.034
Duplicate		Grab	Surface			00-6294					500	100	600	500	0.05	0.04	1.83	1.88	0.717	0.040
Absolute Difference											0	6	14	20	0.01	0.01	0.02	0.01	0.368	0.006
Percent Difference											0	6	2	4	13.33	28.57	1.29	0.64	51.282	13.854
Flandreau Creek	1400	Grab	Surface	09/05/00	T12	00-6318	20	22	9.6	8.2	600	24	552	528	0.58	0.18	0.77	0.95	0.182	0.131
Duplicate		Grab	Surface			00-6320					100	21	605	584	0.56	0.17	0.86	1.04	0.174	0.126
Absolute Difference											500	3	53	56	0.01	0.00	0.09	0.09	0.009	0.004
Percent Difference											83	13	9	10	2.43	2.27	10.76	8.59	4.720	3.438
Jack Moore Creek	1445	Grab	Surface	09/05/00	T13	00-6321	22.1	22	6.1	8.1	1400	13	653	640	0.16	0.15	1.07	1.22	0.230	0.202
Duplicate		Grab	Surface			00-6323					1600	7	627	620	0.16	0.13	1.06	1.18	0.224	0.174
Absolute Difference											200	6	26	20	0.00	0.02	0.01	0.03	0.006	0.028
Percent Difference											13	46	4	3	1.26	16.00	0.94	2.79	2.397	13.713

BSR at USGS Brookings	1040	Grab	Surface	09/06/00	R04	00-6326	17	20	11.3	8.5	600	65	633	568	1.01	0.08	2.24	2.31	0.592	0.192
Duplicate		Grab	Surface			00-6327					600	69	717	648	1.01	0.06	2.11	2.17	0.584	0.221
Absolute Difference											0	4	84	80	0.00	0.02	0.13	0.14	0.008	0.029
Percent Difference											0	6	12	12	0.10	21.05	5.64	6.14	1.336	12.941
Skunk Creek (lower)	1400	Grab	Surface	09/18/00	T23	00-6342	19.9	25	6.3	7.7	50	40	820	780	0.04	0.08	2.36	2.44	0.164	0.042
Duplicate		Grab	Surface			00-6340					40	42	864	822	0.05	0.06	1.24	1.30	0.184	0.041
Absolute Difference											10	2	44	42	0.00	0.02	1.13	1.15	0.020	0.001
Percent Difference											20	5	5	5	6.67	23.75	47.67	46.89	10.773	1.896
Split Rock Ck (lower)	1345	Grab	Surface	09/19/00	T31	00-6350	17.7	18	5.9	8.3	1600	23	399	376	1.25	0.10	1.10	1.20	0.356	0.037
Duplicate		Grab	Surface			00-6349					2000	24	376	352	1.15	0.08	1.51	1.60	0.157	0.027
Absolute Difference											400	1	23	24	0.11	0.02	0.41	0.39	0.199	0.010
Percent Difference											20	4	6	6	8.45	17.00	27.16	24.69	55.967	26.287
BSR at Brandon	1240	Grab	Surface	09/20/00	R12	00-6358	15.7	18	9.9	8.2	230	40	1046	1006	14.97	0.11	2.77	2.88	3.352	3.132
Duplicate		Grab	Surface			00-6359					380	45	1005	960	15.16	0.11	2.54	2.65	3.382	3.181
Absolute Difference											150	5	41	46	0.19	0.00	0.23	0.24	0.031	0.049
Percent Difference											39	11	4	5	1.28	3.67	8.36	8.19	0.905	1.531
Bachelor Creek	1410	Grab	Surface	10/16/00	T14	00-6370	10.2	12	4.3	8.2	1800	6	906	900	1.20	0.14	0.46	0.60	0.088	0.036
Duplicate		Grab	Surface			00-6372					1300	16	896	880	1.20	0.07	0.50	0.57	0.093	0.031
Absolute Difference											500	10	10	20	0.00	0.07	0.04	0.03	0.005	0.005
Percent Difference											28	63	1	2	0.25	47.14	7.88	4.53	5.591	14.246
BSR at USGS N.Cliff Ave.	1340	Grab	Surface	10/18/00	R11	00-6393	15.7	24	10.3	8.9	1200	33	817	784	8.84	0.14	2.21	2.34	2.226	1.990
Duplicate		Grab	Surface			00-6395					1800	35	831	796	8.84	0.11	2.21	2.32	2.034	1.854
Absolute Difference											600	2	14	12	0.00	0.03	0.00	0.02	0.192	0.136
Percent Difference											33	6	2	2	0.05	20.29	0.23	0.98	8.642	6.820
Slip-up Creek	1330	Grab	Surface	10/19/00	T25	00-6379	11.9	24		8.5	2100	13	557	544	3.12	0.07	2.41	2.48	0.281	0.045
Duplicate		Grab	Surface			00-6378					2600	15	619	604	3.43	0.03	2.40	2.43	0.282	0.067
Absolute Difference											500	2	62	60	0.31	0.04	0.01	0.05	0.001	0.022
Percent Difference											19	13	10	10	9.00	55.88	0.46	1.98	0.390	33.033
Skunk Creek (lower)	1400	Grab	Surface	10/19/00	T23	00-6404	16.4	22	10	8.1	40	36	816	780	0.20	0.14	0.81	0.95	0.133	0.005
Duplicate		Grab	Surface			00-6405					40	38	798	760	0.17	0.11	0.77	0.87	0.168	0.009
Absolute Difference											0	2	18	20	0.02	0.03	0.04	0.07	0.035	0.004
Percent Difference											0	5	2	3	12.24	24.46	4.83	7.71	20.962	41.860
Medary Ck (middle)	1145	Grab	Surface	11/01/00	T08	00-6414	16.6	17	5.4	8.1	300	11	551	540	0.14	0.03	0.83	0.86	0.108	0.052

Duplicate		Grab	Surface			00-6413					400	11	523	512	0.15	0.02	0.78	0.79	0.074	0.060
Absolute Difference											100	0	28	28	0.01	0.01	0.05	0.07	0.034	0.008
Percent Difference											25	0	5	5	5.48	46.67	6.60	8.00	31.852	13.478
Skunk Creek (middle)	1030	Grab	Surface	03/21/01	T21	01-6001	0.1	10	9.9	7.6	350	58	378	320	1.16	2.30	2.84	5.14	0.788	0.566
Duplicate		Grab	Surface			01-6002					160	54	330	276	1.14	2.34	2.52	4.86	0.766	0.601
Absolute Difference											190	4	48	44	0.02	0.05	0.33	0.28	0.022	0.035
Percent Difference											54	7	13	14	1.47	2.09	11.46	5.39	2.793	5.822
Pipestone Upper	1030	Grab	Surface	04/02/01	T28	01-6011	0.4	6	10.7	7.4	180	29	201	172	1.94	1.60	1.84	3.44	0.840	0.741
Duplicate		Grab	Surface			01-6010					100	30	190	160	1.94	1.64	1.86	3.49	0.858	0.730
Absolute Difference											80	1	11	12	0.00	0.03	0.02	0.05	0.018	0.011
Percent Difference											44	3	5	7	0.21	1.90	1.08	1.46	2.075	1.524
Brant Lake Outlet	1000	Grab	Surface	04/03/01	T17	01-6023	0.1	8	10.4	9	10	6	-1	-7	0.50	0.86	1.26	2.12	0.247	0.186
Duplicate		Grab	Surface			01-6022					20	6	-1	-7	0.47	0.85	1.19	2.04	0.255	0.174
Absolute Difference											10	0	0	0	0.03	0.01	0.07	0.08	0.008	0.011
Percent Difference											50	3	0	3	6.00	1.05	5.85	3.91	3.021	6.088
BSR at Dell Rapids	945	Grab	Surface	04/04/01	R08	01-6034	0.4	8	9.7	8.5	180	474	742	268	1.44	0.96	2.57	3.53	0.994	0.398
Duplicate		Grab	Surface			01-6033					180	388	652	264	1.44	0.98	2.68	3.66	0.974	0.398
Absolute Difference											0	86	90	4	0.01	0.02	0.11	0.13	0.019	0.001
Percent Difference											0	18	12	1	0.42	1.54	4.10	3.42	1.932	0.176
Pipestone Upper	715	Grab	Surface	04/12/01	T28	01-6054	4.9	5	6.2	7.9	4000	64	508	444	3.99	0.52	1.75	2.27	0.600	0.443
Duplicate		Grab	Surface			01-6053					3800	56	472	416	3.92	0.52	1.67	2.20	0.590	0.431
Absolute Difference											200	8	36	28	0.07	0.01	0.08	0.07	0.010	0.011
Percent Difference											5	13	7	6	1.71	0.96	4.29	3.09	1.666	2.575
BSR at Western Ave	1245	Grab	Surface	04/12/01	R10	01-6068	7.1	11	3.1	7.5	5800	212	644	432	1.56	0.47	1.92	2.39	0.740	0.358
Duplicate		Grab	Surface			01-6069					6000	209	557	348	1.56	0.49	1.94	2.43	0.702	0.353
Absolute Difference											200	3	87	84	0.00	0.02	0.02	0.04	0.038	0.005
Percent Difference											3	1	14	19	0.00	3.07	1.24	1.60	5.147	1.315
Brant Lake Outlet	945	Grab	Surface	04/12/01	T17	01-6073	4.1	7.4		7.8	20	10	-1	-11	0.34	0.71	1.34	2.05	0.237	0.159
Duplicate		Grab	Surface			01-6074					10	16	-1	-17	0.33	0.63	1.61	2.24	0.227	0.154
Absolute Difference											10	6	0	6	0.01	0.08	0.27	0.19	0.010	0.006
Percent Difference											50	38	0	35	2.94	11.16	16.67	8.58	4.219	3.518
Pipestone Upper	1000	Grab	Surface	04/23/01	T28	01-6096	1.8	5	5.6	8.2	13000	200	405	205	3.00	0.37	2.38	2.75	0.762	0.329
Duplicate		Grab	Surface	04/23/01		01-6095					12000	210	440	230	2.95	0.40	2.52	2.92	0.788	0.344
Absolute Difference											1000	10	35	25	0.05	0.03	0.14	0.17	0.026	0.015

Percent Difference											8	5	8	11	1.67	6.97	5.56	5.75	3.261	4.446
Skunk Creek (upper)	1545	Grab	Surface	04/23/01	T23	01-6123	4.3	13	9.9	7.7	26000	154	486	332	1.34	0.55	2.15	2.70	0.833	0.280
Duplicate		Grab	Surface	04/23/01		01-6124					350000	180	544	364	1.32	0.50	2.16	2.66	0.858	0.274
Absolute Difference											324000	26	58	32	0.02	0.05	0.01	0.04	0.025	0.006
Percent Difference											93	14	11	9	1.64	8.73	0.51	1.37	2.868	2.108
BSR @ Dell Rapids	1000	Grab	Surface	04/24/01	R08	01-6107	5.7	10	10.1	8.0	7900	134	409	275	1.25	0.24	1.56	1.80	0.566	0.275
Duplicate		Grab	Surface	04/24/01		01-6106					7300	126	391	265	1.24	0.27	1.60	1.87	0.584	0.263
Absolute Difference											600	8	18	10	0.01	0.04	0.04	0.08	0.018	0.011
Percent Difference											8	6	4	4	1.04	14.23	2.25	4.00	3.033	4.114
Skunk Creek Upper	1500	Grab	Surface	05/07/01	T18	01-6134	14.4	15.5	7.6	7.8	200	11	821	810	0.29	0.12	1.44	1.57	0.129	0.090
Duplicate		Grab	Surface	05/07/01		01-6135					99	17	853	836	0.29	0.09	1.10	1.19	0.133	0.065
Absolute Difference											101	6	32	26	0.00	0.03	0.35	0.38	0.004	0.025
Percent Difference											51	35	4	3	0.35	25.41	23.96	24.07	2.792	27.374
Pipestone Upper	940	Grab	Surface	05/07/01	T28	01-6139	11.8	12	7.5	8.2	1800	28	500	472	5.49	0.19	1.60	1.79	0.285	0.206
Duplicate		Grab	Surface	05/07/01		01-6138					1700	31	491	460	5.47	0.20	1.57	1.76	0.289	0.226
Absolute Difference											100	3	9	12	0.02	0.01	0.04	0.03	0.005	0.020
Percent Difference											6	10	2	3	0.40	2.56	2.31	1.78	1.659	8.688
BSR nr Dell Rapids	1145	Grab	Surface	05/08/01	R08	01-6162	14.8	23	8.7	7.7	400	26	606	580	0.47	0.11	1.10	1.21	0.231	0.162
Duplicate		Grab	Surface	05/08/01		01-6161					500	31	587	556	0.47	0.09	1.07	1.16	0.225	0.159
Absolute Difference											100	5	19	24	0.01	0.02	0.03	0.05	0.006	0.003
Percent Difference											20	16	3	4	1.27	14.29	2.91	3.90	2.597	1.852
Brant Lake Outlet	1000	Grab	Surface	06/04/01	T17	01-6170	15.8	18	11.3	8.1	99	34	-1	-35	0.23	0.46	1.64	2.11	0.197	0.074
Duplicate		Grab	Surface	06/04/01		01-6169					200	36	-1	-37	0.24	0.46	1.55	2.01	0.186	0.073
Absolute Difference											101	2	0	2	0.00	0.01	0.10	0.10	0.011	0.002
Percent Difference											51	6	0	5	1.69	1.08	5.84	4.79	5.344	2.151
Pipestone Upper	945	Grab	Surface	06/05/01	T28	01-6179	13.5	15	10.6	8.6	1000	34	694	660	6.11	0.11	1.95	2.06	0.504	0.335
Duplicate		Grab	Surface	06/05/01		01-6181					1100	30	610	580	6.29	0.11	1.93	2.04	0.523	0.346
Absolute Difference											100	4	84	80	0.18	0.00	0.02	0.02	0.019	0.011
Percent Difference											9	12	12	12	2.80	1.82	0.77	0.83	3.633	3.179
BSR nr Dell Rapids	1000	Grab	Surface	06/06/01	R08	01-6196	16.4	19	12.5	8.3	100	49	1301	1252	0.52	0.04	1.12	1.15	0.233	0.131
Duplicate		Grab	Surface	06/06/01		01-6195					99	43	1227	1184	0.53	0.06	1.55	1.61	0.215	0.125
Absolute Difference											1	6	74	68	0.01	0.02	0.43	0.45	0.018	0.006
Percent Difference											1	12	6	5	1.51	35.59	27.91	28.19	7.725	4.580

Pipestone Upper	900	Grab	Surface	06/13/01	T28	01-6199	16.8	16	6.7	8.6	25000	284	779	495	5.52	0.46	2.83	3.29	0.983	0.327
Duplicate		Grab	Surface	06/13/01		01-6200					33000	280	750	470	5.18	0.50	2.72	3.22	0.983	0.330
Absolute Difference											8000	4	29	25	0.34	0.04	0.11	0.07	0.000	0.003
Percent Difference											24	1	4	5	6.15	8.57	3.89	2.04	0.000	0.909
Willow Creek	1345	Grab	Surface	06/13/01	T22	01-6907	19.5	29	6.4	7.7	60000	408	696	288	2.80	0.39	3.27	3.66	1.220	0.353
Duplicate		Grab	Surface	06/13/01		01-6909					13000	408	672	264	2.80	0.36	3.50	3.85	1.194	0.373
Absolute Difference											47000	0	24	24	0.00	0.03	0.23	0.19	0.026	0.020
Percent Difference											78	0	3	8	0.14	8.72	6.52	5.03	2.131	5.362
Brant Lake Outlet	1000	Grab	Surface	07/09/01	T17	01-6233	25.2	30	5.4	8.2	80	17	1205	1188	0.07	0.32	1.55	1.87	0.134	0.069
Duplicate		Grab	Surface	07/09/01		01-6232					250	16	1196	1180	0.07	0.28	1.68	1.96	0.127	0.071
Absolute Difference											170	1	9	8	0.00	0.04	0.13	0.09	0.007	0.002
Percent Difference											68	6	1	1	4.23	13.13	7.56	4.34	5.224	2.817
BSR @ Dell Rapids	1045	Grab	Surface	07/10/01	R08	01-6256	27.2	34	4.4	8.1	70	112	856	744	0.93	0.13	1.14	1.27	0.166	0.290
Duplicate		Grab	Surface	07/10/01		01-6255					140	110	854	744	0.94	0.09	1.18	1.27	0.272	0.169
Absolute Difference											70	2	2	0	0.00	0.04	0.03	0.00	0.106	0.121
Percent Difference											50	2	0	0	0.53	30.77	2.98	0.39	38.971	41.724
Pipestone Creek (Upper)	1000	Grab	Surface	07/09/01	T28	01-6245	23.9	27	7.4	8.2	800	52	628	576	6.63	0.09	1.49	1.58	0.148	0.272
Duplicate		Grab	Surface	07/09/01		01-6242					700	47	635	588	6.75	0.10	1.64	1.74	0.330	0.257
Absolute Difference											100	5	7	12	0.13	0.01	0.15	0.16	0.182	0.015
Percent Difference											13	10	1	2	1.91	11.11	9.19	9.30	55.152	5.515
Skunk Creek (lower)	1315	Grab	Surface	07/23/01	T23	01-6269	27.8	34	12.9	8.2	4600	93	789	696	1.03	0.10	1.56	1.66	0.249	0.065
Duplicate		Grab	Surface	07/23/01		01-6263					2500	96	736	640	1.00	0.09	1.27	1.36	0.285	0.074
Absolute Difference											2100	3	53	56	0.03	0.01	0.30	0.31	0.036	0.009
Percent Difference											46	3	7	8	3.11	11.76	18.95	18.51	12.632	12.162
Pipestone Creek (Upper)	930	Grab	Surface	07/23/01	T28	01-6274	25.2	26	7.1	8.4	17000	67	515	448	3.72	0.14	1.07	1.20	0.270	0.164
Duplicate		Grab	Surface	07/23/01		01-6272					5100	56	540	484	3.75	0.14	1.19	1.33	0.292	0.180
Absolute Difference											11900	11	25	36	0.03	0.00	0.12	0.12	0.022	0.016
Percent Difference											70	16	5	7	0.80	0.72	10.27	9.28	7.534	8.889
BSR @ Western Ave	1400	Grab	Surface	07/24/01	R10	01-6294	23.3	21	11.5	8.3	11000	703	1091	388	0.81	0.25	1.93	2.17	1.249	0.133
Duplicate		Grab	Surface	07/24/01		01-6296					21000	723	1091	368	0.79	0.21	1.88	2.09	1.136	0.140
Absolute Difference											10000	20	0	20	0.03	0.04	0.05	0.09	0.113	0.007
Percent Difference											48	3	0	5	3.44	15.04	2.65	4.05	9.047	5.000
Brant Lake Outlet	1000	Grab	Surface	08/13/01	T17	01-6926	21.5	21	9.7	7.8	99	11	1231	1220	0.40	0.76	1.61	2.37	0.351	0.273

Duplicate		Grab	Surface	08/13/01		01-6925					99	13	1233	1220	0.39	0.75	1.54	2.29	0.329	0.300
Absolute Difference											0	2	2	0	0.01	0.01	0.07	0.08	0.022	0.027
Percent Difference											0	15	0	0	2.76	0.66	4.28	3.17	6.268	9.000
Pipestone Creek (Upper)	930	Grab	Surface	08/14/01	T28	01-6944	19.5	17.5	5.7	8.2	2400	90	608	518	2.20	0.06	1.55	1.60	0.264	0.032
Duplicate		Grab	Surface	08/14/01		01-6943					1500	90	590	500	2.17	0.09	1.64	1.73	0.272	0.022
Absolute Difference											900	0	18	18	0.03	0.03	0.10	0.13	0.008	0.010
Percent Difference											38	0	3	3	1.36	35.87	5.91	7.50	2.941	31.250
BSR@ Dell Rapids	1030	Grab	Surface	08/14/01	R08	01-6937	23.3	20	7.5	8.6	100	95	959	864	0.03	0.07	1.95	2.01	0.378	0.126
Duplicate		Grab	Surface	08/14/01		01-6936					30	103	939	836	0.05	0.02	1.93	1.96	0.370	0.116
Absolute Difference											70	8	20	28	0.01	0.04	0.01	0.05	0.008	0.010
Percent Difference											70	8	2	3	30.43	64.62	0.62	2.69	2.116	7.937
Brant Lake Outlet	915	Grab	Surface	09/10/01	T17	01-6352	14.1	14	14.3	8.6	330	3	1091	1088	0.36	0.09	0.83	0.92	0.153	0.137
Duplicate		Grab	Surface	09/10/01		01-6351					320	2	1058	1056	0.36	0.08	0.69	0.77	0.150	0.135
Absolute Difference											10	1	33	32	0.00	0.02	0.13	0.15	0.003	0.002
Percent Difference											3	33	3	3	0.55	16.67	16.22	16.27	1.961	1.460
Pipestone Creek (Upper)	930	Grab	Surface	09/11/01	T28	01-6362	15.8	17.5	11.2	8.1	1600	68	512	444	2.30	0.18	1.26	1.43	0.263	0.089
Duplicate		Grab	Surface	09/11/01		01-6361					1600	66	546	480	2.28	0.15	1.19	1.34	0.251	0.085
Absolute Difference											0	2	34	36	0.02	0.02	0.07	0.09	0.012	0.004
Percent Difference											0	3	6	8	0.87	12.50	5.42	6.29	4.563	4.494
BSR at Dell Rapids	915	Grab	Surface	09/12/01	R08	01-6374	20	18.5	7	8.8	110	108	928	820	0.06	0.08	2.35	2.43	0.385	0.090
Duplicate		Grab	Surface	09/12/01		01-6373					70	116	912	796	0.07	0.05	2.19	2.24	0.396	0.090
Absolute Difference											40	8	16	24	0.01	0.03	0.16	0.19	0.011	0.000
Percent Difference											36	7	2	3	10.00	34.94	6.98	7.93	2.778	0.000
Skunk Creek (lower)	1500	Grab	Surface	10/09/01	T23	01-6418	14.4	17	11.4	7.8	80	30	874	844	0.33	0.23	0.92	1.15	0.096	0.012
Duplicate		Grab	Surface	10/09/01		01-6416					100	26	978	952	0.35	0.26	0.89	1.15	0.124	0.014
Absolute Difference											20	4	104	108	0.03	0.03	0.03	0.00	0.028	0.002
Percent Difference											20	13	11	11	7.34	10.00	3.26	0.35	22.581	14.286
BSR @ N. Cliff Ave	830	Grab	Surface	10/09/01	R11	01-6421	15.3	13	16.5	8.4	50	75	907	832	4.19	0.07	2.46	2.53	0.620	0.395
Duplicate		Grab	Surface	10/09/01		01-6420					100	72	848	776	4.19	0.07	2.49	2.56	0.625	0.408
Absolute Difference											50	3	59	56	0.00	0.00	0.03	0.03	0.005	0.013
Percent Difference											50	4	7	7	0.10	2.90	1.29	1.33	0.800	3.186
Pipestone Creek (Upper)	1000	Grab	Surface	10/10/01	T28	01-6429	13.3	10	14.4	8.4	5100	31	863	832	2.72	0.71	1.64	2.35	0.578	0.394
Duplicate		Grab	Surface	10/10/01		01-6428					7000	35	831	796	2.77	0.72	1.55	2.27	0.427	0.390

Absolute Difference			1900	4	32	36	0.05	0.01	0.09	0.08	0.151	0.004
Percent Difference			27	11	4	4	1.66	0.84	5.37	3.49	26.125	1.015
BLANK	03/13/00	00-6012	0	0	64	64	0.06	0.00	0.41	0.41	0.000	0.000
BLANK	04/10/00	00-6030	0	0	20	20	0.06	0.00	0.02	0.01	0.000	0.000
BLANK	04/11/00	00-6043	0	0	1	1	0.04	0.00	0.07	0.07	0.000	0.000
BLANK	05/09/00	00-6058	0	0	1	1	0.11	0.00	0.36	0.36	0.000	0.000
BLANK	05/09/00	00-6066	0	0	16	16	0.04	0.00	0.04	0.08	0.531	0.007
BLANK	05/16/00	00-6083	0	0	24	24	0.04	0.00	0.10	0.10	0.013	0.000
BLANK	05/19/00	00-6096		0	1	1	0.05	0.03	0.01	0.04	0.027	0.000
BLANK	05/31/00	00-6116	0	0	1	1	0.06	0.04	0.02	0.06	0.020	0.016
BLANK	06/02/00	00-6124	0	0	0	0	0.06	0.03	0.36	0.39	0.012	0.000
BLANK	06/12/00	00-6139	0	0	28	28	0.08	0.00	0.02	0.02	0.022	0.011
BLANK	06/13/00	00-6143	0	0	25	25	0.05	0.00	0.03	0.03	0.000	0.000
BLANK	06/13/00	00-6164	0	0	1	1	0.04	0.04	0.04	0.08	0.035	0.016
BLANK	06/14/00	00-6173	0	0	0	0	0.08	0.00	0.08	0.08	0.000	0.000
BLANK	06/28/00	00-6187	0	0	0	0	0.03	0.00	0.27	0.27	0.000	0.000
BLANK	06/28/00	00-6189	0	0	16	16	0.05	0.02	0.03	0.05	0.000	0.000
BLANK	07/10/00	00-6199	0	0	16	16	0.05	0.02	0.35	0.37	0.000	0.000
BLANK	07/11/00	00-6212	0	0	24	24	0.05	0.00	0.31	0.31	0.000	0.000
BLANK	07/11/00	00-6213	0	0	16	16	0.05	0.00	0.06	0.06	0.000	0.000
BLANK	07/12/00	00-6228	0	0	0	0	0.05	0.02	0.00	0.02	0.018	0.000
BLANK	07/13/00	00-6235	0	0	0	0	0.05	0.00	0.07	0.07	0.030	0.013
BLANK	07/13/00	00-6236	0	0	0	0	0.06	0.00	0.00	0.00	0.000	0.000
BLANK	07/13/00	00-6237	0	0	0	0	0.04	0.03	0.09	0.11	0.000	0.000
BLANK	07/14/00	00-6252	0	0	0	0	0.05	0.02	0.04	0.05	0.011	0.000
BLANK	07/14/00	00-6255	0	0	0	0	0.04	0.01	0.03	0.04	0.020	0.000
BLANK	08/14/00	00-6263	0	0	0	0	0.05	0.00	0.00	0.00	0.000	0.000
BLANK	08/14/00	00-6274	0	0	0	0	0.05	0.00	0.00	0.00	0.000	0.000
BLANK	08/15/00	00-6277	0	0	0	0	0.04	0.00	0.26	0.26	0.000	0.000
BLANK	08/16/00	00-6288	0	0	4	4	0.04	0.03	0.48	0.51	0.021	0.012
BLANK	08/16/00	00-6296	0	0	0	0	0.04	0.00	0.04	0.04	0.015	0.000
BLANK	09/05/00	00-6319	0	0	0	0	0.04	0.00	0.06	0.06	0.000	0.000
BLANK	09/05/00	00-6322	0	0	0	0	0.03	0.00	0.50	0.50	0.000	0.000
BLANK	09/06/00	00-6328	0	0	0	0	0.04	0.00	0.04	0.04	0.000	0.000
BLANK	09/18/00	00-6341	0	0	40	40	0.04	0.00	0.00	0.00	0.000	0.000
BLANK	09/19/00	00-6346	0	0	0	0	0.04	0.00	0.02	0.02	0.000	0.000
BLANK	09/20/00	00-6360	0	0	0	0	0.06	0.00	0.07	0.07	0.000	0.000
BLANK	10/16/00	00-6271	0	0	16	16	0.05	0.00	0.29	0.29	0.021	0.010
BLANK	10/18/00	00-6394	0	0	0	0	0.19	0.00	0.00	0.00	0.000	0.000
BLANK	10/19/00	00-6376	0	0	0	0	0.03	0.00	0.00	0.00	0.000	0.000

BLANK	10/19/00	00-6406	0	0	0	0	0.06	18.00	0.30	0.32	0.017	0.015
BLANK	11/01/00	00-6408	0	0	0	0	0.04	0.00	0.04	0.04	0.019	0.000
BLANK	03/21/01	01-6003	0	1	1	0	0.06	0.03	0.04	0.07	0.009	0.010
BLANK	04/02/01	01-6009	0	1	15	15	0.04	0.89	0.50	1.40	0.005	0.005
BLANK	04/03/01	01-6021	1	1	12	12	0.04	0.01	0.05	0.05	0.005	0.005
BLANK	04/04/01	01-6032	1	1	10	10	0.05	0.01	0.22	0.22	0.005	0.005
BLANK	04/12/01	01-6052	0	1	25	24	0.06	0.02	0.37	0.39	0.005	0.005
BLANK	04/12/01	01-6070	0	1	31	30	0.04	0.02	0.48	0.50	0.005	0.005
BLANK	04/12/01	01-6075	0	1	1	0	0.06	0.01	0.03	0.04	0.005	0.005
BLANK	04/23/01	01-6094	0	0	0	0	0.03	0.00	0.21	0.21	0.000	0.000
BLANK	04/23/01	01-6125	0	1	0	-1	0.05	0.01	0.33	0.34	0.000	0.000
BLANK	04/24/01	01-6105	0	1	1	0	0.04	0.01	0.30	0.31	0.005	0.005
BLANK	05/07/01	01-6136	0	0	6	6	0.03	0.00	0.02	0.02	0.000	0.000
BLANK	05/07/01	01-6137	0	1	4	4	0.04	0.01	0.46	0.46	0.005	0.005
BLANK	05/08/01	01-6160	0	0	0	0	0.03	0.00	0.30	0.30	0.000	0.000
BLANK	06/04/01	01-6168	0	1	14	14	0.19	0.01	0.45	0.45	0.005	0.005
BLANK	06/05/01	01-6180	0	0	0	0	0.08	0.00	0.50	0.50	0.000	0.000
BLANK	06/06/01	01-6194	0	0	0	0	0.05	0.01	0.03	0.04	0.000	0.003
BLANK	06/13/01	01-6201	0	0	0	0	0.23	0.00	0.00	0.00	0.009	0.010
BLANK	06/13/01	01-6908	0	0	0	0	0.06	0.00	0.42	0.42	0.004	0.006
BLANK	07/09/01	01-6231	0	0	0	0	0.04	0.01	0.50	0.51	0.000	0.000
BLANK	07/10/01	01-6254	0	0	0	0	0.03	0.00	0.34	0.34	0.001	0.001
BLANK	07/09/01	01-6243	0	0	0	0	0.06	0.00	0.47	0.47	0.003	0.000
BLANK	07/23/01	01-6262	0	0	8	8	0.04	0.00	0.47	0.47	0.000	0.000
BLANK	07/23/01	01-6273	0	0	0	0	0.04	0.00	0.43	0.43	0.000	0.000
BLANK	07/24/01	01-6297	200	0	0	0	0.03	0.00	0.32	0.32	0.000	0.000
BLANK	08/13/01	01-6924	0	0	0	0	0.03	0.00	0.37	0.37	0.001	0.004
BLANK	08/14/01	01-6942	0	0	0	0	0.05	0.00	0.42	0.42	0.000	0.000
BLANK	08/14/01	01-6935	0	0	12	12	0.03	0.00	0.43	0.43	0.002	0.000
BLANK	09/10/01	01-6350	0	0	0	0	0.08	0.00	0.43	0.43	0.000	0.000
BLANK	09/11/01	01-6360	0	0	0	0	0.03	0.03	0.45	0.47	0.000	0.002
BLANK	09/12/01	01-6372	0	0	0	0	0.07	0.00	0.41	0.41	0.000	0.000
BLANK	10/09/01	01-6417	0	0	0	0	0.04	0.00	0.02	0.02	0.000	0.003
BLANK	10/09/01	01-6419	0	0	54	54	0.03	0.00	0.48	0.48	0.018	0.014
BLANK	10/10/01	01-6427	0	0	12	12	0.03	0.00	0.48	0.48	0.019	0.000

Appendix T.
WQ Parameters – FLUX Yearly Loads, Concentrations, and CV's

R01

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	159451	19769870	0.133
TotSol	902178	111682600	0.031
DisSol	731234	90521080	0.053
NO2NO3	151	18693	0.212
NH3N	59	7353	0.196
Orgntr	------------ not enough data to run FLUX --------------		
TKN	2051	254278	0.095
TotPO4	396	49133	0.082
TotDisPO4	33	4087	0.076
Fecal	230956	28635540	0.248
DO	8609	1067444	0.067

R02

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	142009	18799530	0.080
TotSol	808478	107028300	0.056
DisSol	668114	88446560	0.058
NO2NO3	205	27135	0.360
NH3N	104	13809	0.167
Orgntr	2100	278041	0.064
TKN	2205	291843	0.060
TotPO4	402	53243	0.086
TotDisPO4	86	11340	0.224
Fecal	760707	101000000	0.624
DO	8217.52	1087855	0.055

R03

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	172018	24918310	0.116
TotSol	923093	133718300	0.033
DisSol	748277	108394600	0.050
NO2NO3	268	38868	0.155
NH3N	84	12199	0.145
Orgntr	------------ not enough data to run FLUX --------------		
TKN	2119	306958	0.127
TotPO4	472	68324	0.069
TotDisPO4	88	12816	0.095
Fecal	271900	39387140	0.288
DO	8861	1283638	0.060

R04

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	145755	22082690	0.125
TotSol	808442	122483100	0.039
DisSol	659308	99888610	0.052
NO2NO3	551	83435	0.157
NH3N	87	13236	0.120
Orgntr	2120	321198	0.071
TKN	2214	335447	0.070
TotPO4	458	69336	0.067
TotDisPO4	115	17375	0.129
Fecal	2169488	328688600	0.801
DO	8389	1270925	0.054

R05

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	142848	22463800	0.104
TotSol	754645	118672800	0.033
DisSol	621000	97656220	0.034
NO2NO3	451	70889	0.215
NH3N	83	13066	0.207
Orgntr	2055	323107	0.067
TKN	2145	337293	0.068
TotPO4	403	63387	0.114
TotDisPO4	98	15370	0.125
Fecal	1148834	180661500	0.756
DO	8523	1340358	0.056

R06

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	129305	24929350	0.093
TotSol	690876	133197800	0.033
DisSol	569648	109825700	0.035
NO2NO3	418	80681	0.241
NH3N	111	21359	0.16
Orgntr	1965	378900	0.039
TKN	2077	400453	0.037
TotPO4	360	69404	0.03
TotDisPO4	88	17052	0.148
Fecal	1065009	205329100	0.564
DO	8837	1703678	0.043

R07

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	139687	28278270	0.074
TotSol	755933	153031100	0.02
DisSol	618119	125132100	0.039
NO2NO3	431	87328	0.186
NH3N	84	17090	0.111
Orgntr	2074	419860	0.036
TKN	2163	437860	0.036
TotPO4	385	77968	0.03
TotDisPO4	87	17585	0.213
Fecal	2166530	438592500	0.685
DO	9431	1909239	0.036

R08

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	120472	127764900	0.288
TotSol	712732	755879200	0.058
DisSol	555492	589119600	0.088
NO2NO3	1184	1255806	0.13
NH3N	330	349499	0.323
Orgntr	1719	1823236	0.095
TKN	2049	2172735	0.128
TotPO4	529	561223	0.139
TotDisPO4	271	287060	0.115
Fecal	5677494	6021194000	0.551
DO	8683	9208210	0.082

R09

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	170070	181803500	0.224
TotSol	626404	669622800	0.092
DisSol	490527	524370700	0.058
NO2NO3	1406	1503099	0.196
NH3N	355	379552	0.295
Orgntr	1881	2011252	0.117
TKN	2237	2390804	0.135
TotPO4	659	704517	0.142
TotDisPO4	209	223358	0.072
Fecal	10260150	10968040000	0.481
DO	8715	9316638	0.085

R10

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	261593	41549560	0.386
TotSol	876146	144743800	0.059
DisSol	634816	104874800	0.067
NO2NO3	1192	196933	0.593
NH3N	223	36906	0.484
Orgntr	1676	276881	0.256
TKN	1834	302915	0.278
TotPO4	625	103281	0.371
TotDisPO4	232	38373	0.14
Fecal	5201752	859355600	0.528
DO	9957	1644923	0.063

R11

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	186896	238578000	0.177
TotSol	722806	922680400	0.035
DisSol	474670	605927900	0.074
NO2NO3	1708	2180398	0.116
NH3N	316	403681	0.270
Orgntr	1938	2473307	0.098
TKN	2255	2878700	0.113
TotPO4	661	843585	0.110
TotDisPO4	296	377427	0.072
Fecal	6979134	8909042000	0.362
DO	9779	12482800	0.177

R12

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	201358	161033700	0.258
TotSol	831353	664864800	0.147
DisSol	630775	504454700	0.042
NO2NO3	1467	1173200	0.136
NH3N	122	97729	0.304
Orgntr	1831	1464201	0.177
TKN	1953	1561930	0.185
TotPO4	634	506805	0.253
TotDisPO4	265	211638	0.09
Fecal	7389154	5909386000	0.625
DO	9408	7524305	0.056

R13

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	506805	581038500	0.615
TotSol	986063	1130494000	0.216
DisSol	547313	627479200	0.126
NO2NO3	2114	2424116	0.137
NH3N	278	318839	0.604
Orgntr	2887	3309653	0.416
TKN	3127	3585031	0.431
TotPO4	1119	1283016	0.528
TotDisPO4	259	297135	0.065
Fecal	35031220	40162360000	0.856
DO	8422	9655643	0.104

T01

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	14241	57496	0.130
TotSol	495722	2001423	0.056
DisSol	481297	1943182	0.056
NO2NO3	78	314	0.172
NH3N	111	448	0.181
Orgntr	1062	4289	0.127
TKN	1172	4731	0.116
TotPO4	151	610	0.202
TotDisPO4	104	418	0.236
Fecal	666770	2692009	0.532
DO	6434	25978	0.152

T02

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	71854	510746	0.498
TotSol	534122	3796593	0.083
DisSol	477584	3394712	0.153
NO2NO3	240	1708	0.501
NH3N	135	960	0.290
Orgntr	1228	8729	0.078
TKN	1236	8789	0.088
TotPO4	247	1754	0.417
TotDisPO4	119	848	0.406
Fecal	9804155	69946020	0.902
DO	7678	54573	0.133

T03

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	35349	79366	0.144
TotSol	504629	1132995	0.098
DisSol	469280	1053629	0.114
NO2NO3	464	1042	0.248
NH3N	163	367	0.258
Orgntr	1299	2916	0.098
TKN	1470	3301	0.092
TotPO4	142	319	0.199
TotDisPO4	41	91	0.184
Fecal	828832	1860896	0.616
DO	12496	28055	0.197

T04

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	71967	467939	0.376
TotSol	607834	3952197	0.021
DisSol	500638	3255201	0.027
NO2NO3	841	5469	0.132
NH3N	195	1265	0.242
Orgntr	1277	8305	0.145
TKN	1356	8817	0.142
TotPO4	242	1571	0.212
TotDisPO4	54	353	0.143
Fecal	5917410	38451550	0.430
DO	7280	47336	0.093

T05

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	79553	406496	0.173
TotSol	445646	2277152	0.105
DisSol	363010	1854900	0.119
NO2NO3	466	2381	0.130
NH3N	332	1695	0.235
Orgntr	1256	6416	0.071
TKN	1576	8054	0.084
TotPO4	330	1688	0.110
TotDisPO4	134	685	0.137
Fecal	7963636	40692450	0.384
DO	6952	35524	0.074

T06

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	115608	611855	0.315
TotSol	753019	3985364	0.073
DisSol	616712	3263957	0.054
NO2NO3	304	1610	0.211
NH3N	138	730	0.101
Orgntr	1312	6942	0.152
TKN	1450	7672	0.138
TotPO4	268	1420	0.270
TotDisPO4	64	336	0.357
Fecal	1071187	5669274	0.143
DO	8249	43657	0.058

T07

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	26092	123382	0.185
TotSol	413026	1953067	0.055
DisSol	381072	1801966	0.094
NO2NO3	2010	9503	0.094
NH3N	103	489	0.123
Orgntr	1123	5309	0.055
TKN	1232	5825	0.063
TotPO4	130	616	0.125
TotDisPO4	51	241	0.228
Fecal	959354	4536478	0.409
DO	9352	44223	0.071

T08

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	33945	289528	0.107
TotSol	477290	4070923	0.092
DisSol	429032	3659324	0.141
NO2NO3	878	7487	0.135
NH3N	121	1031	0.152
Orgntr	1141	9736	0.073
TKN	1267	10810	0.073
TotPO4	191	1632	0.141
TotDisPO4	90	766	0.426
Fecal	1709231	14578460	0.491
DO	9313	79434	0.082

T09

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	73745	1197876	0.253
TotSol	575220	9343581	0.020
DisSol	503477	8178221	0.024
NO2NO3	805	13084	0.104
NH3N	134	2174	0.069
Orgntr	1073	17430	0.087
TKN	1294	21020	0.081
TotPO4	187	3036	0.258
TotDisPO4	59	953	0.329
Fecal	1498066	24333810	0.340
DO	8613	139900	0.063

T10

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	29505	154194	0.062
TotSol	1593772	8329040	0.009
DisSol	1560828	8156875	0.007
NO2NO3	122	639	0.439
NH3N	357	1864	0.169
Orgntr	1412	7379	0.094
TKN	1653	8639	0.179
TotPO4	145	759	0.144
TotDisPO4	43	224	0.076
Fecal	141221	738018	0.467
DO	8289	43319	0.018

T11

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	36704	303884	0.166
TotSol	500153	4140936	0.038
DisSol	468227	3876611	0.037
NO2NO3	2187	18105	0.091
NH3N	151	1247	0.078
Orgntr	1155	9564	0.039
TKN	481	3981	0.194
TotPO4	175	1445	0.145
TotDisPO4	6373	52761	0.123
Fecal	3567256	29534510	0.090
DO	8672	71798	0.063

T12

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	175904	1893263	0.614
TotSol	526572	5667532	0.033
DisSol	478715	5152445	0.049
NO2NO3	921	9908	0.344
NH3N	182	1964	0.093
Orgntr	1373	14783	0.273
TKN	1529	16452	0.316
TotPO4	390	4201	0.516
TotDisPO4	142	1530	0.430
Fecal	5882441	63313080	0.202
DO	7443	80114	0.080

T13

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	49690	112034	0.182
TotSol	781242	1761431	0.195
DisSol	789297	1779591	0.147
NO2NO3	746	1682	0.223
NH3N	148	333	0.168
Orgntr	1571	3543	0.030
TKN	1632	3679	0.054
TotPO4	335	756	0.092
TotDisPO4	240	541	0.145
Fecal	11380080	25730260	0.083
DO	6935	15635	0.086

T14

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	115909	632669	0.078
TotSol	1140881	6227308	0.044
DisSol	952504	5199084	0.086
NO2NO3	1431	7813	0.266
NH3N	253	1383	0.252
Orgntr	1874	10227	0.258
TKN	2090	11406	0.285
TotPO4	400	2185	0.436
TotDisPO4	250	1363	0.241
Fecal	19307460	105858800	0.143
DO	8326	45447	0.060

T15

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	42959	1086399	0.194
TotSol	664168	16796260	0.166
DisSol	661046	16717310	0.182
NO2NO3	1097	27749	0.166
NH3N	253	6400	0.348
Orgntr	1348	34091	0.091
TKN	1602	40527	0.082
TotPO4	412	10412	0.128
TotDisPO4	312	7898	0.198
Fecal	5463285	138162000	0.401
DO	9414	238061	0.030

T16

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	132046	3454216	0.317
TotSol	1040376	27215310	0.119
DisSol	910671	23822330	0.099
NO2NO3	426	11136	0.143
NH3N	436	11404	0.149
Orgntr	3247	84930	0.189
TKN	2741	71698	0.139
TotPO4	508	13293	0.060
TotDisPO4	203	5301	0.394
Fecal	51162	1338348	0.279
DO	9192	240453	0.041

T17

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	26618	3517593	0.312
TotSol	1238420	163659600	0.019
DisSol	1192256	157559000	0.012
NO2NO3	256	33869	0.151
NH3N	398	52578	0.197
Orgntr	1487	196533	0.078
TKN	1902	251413	0.086
TotPO4	200	26407	0.154
TotDisPO4	95	12607	0.179
Fecal	3347429	442369400	0.648
DO	8530	1127197	0.107

T18

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	75043	5861407	0.289
TotSol	775667	60585500	0.113
DisSol	722500	56432740	0.124
NO2NO3	608	47494	0.206
NH3N	348	27172	0.380
Orgntr	1492	116561	0.063
TKN	1842	143882	0.091
TotPO4	471	36769	0.217
TotDisPO4	214	16696	0.301
Fecal	2133208	166619900	0.425
DO	9358	730927	0.067

T19

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	225628	5021330	0.466
TotSol	611149	13601100	0.262
DisSol	385522	8579765	0.164
NO2NO3	3016	67127	0.162
NH3N	366	8154	0.051
Orgntr	2502	55684	0.261
TKN	2891	64333	0.223
TotPO4	1093	24329	0.194
TotDisPO4	560	12457	0.123
Fecal	92354800	2415596000	0.426
DO	8768	229338	0.150

T20

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	80856	2951049	0.242
TotSol	769757	28094310	0.127
DisSol	624051	22776400	0.098
NO2NO3	1542	56268	0.081
NH3N	573	20929	0.069
Orgntr	1808	65990	0.080
TKN	2402	87680	0.069
TotPO4	725	26472	0.106
TotDisPO4	426	15532	0.036
Fecal	3779889	137957000	0.174
DO	8950	326665	0.073

T21

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	264951	44805690	0.204
TotSol	943761	159598800	0.094
DisSol	721183	121958600	0.150
NO2NO3	1117	188940	0.078
NH3N	433	73167	0.111
Orgntr	1953	330308	0.059
TKN	2384	403207	0.063
TotPO4	719	121579	0.117
TotDisPO4	294	49645	0.099
Fecal	2045616	345932500	0.260
DO	8451	1429102	0.043

T22

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	284503	5736657	0.678
TotSol	551482	11119940	0.263
DisSol	314157	6334581	0.064
NO2NO3	2595	52331	0.108
NH3N	386	7787	0.051
Orgntr	2692	54279	0.285
TKN	3094	62394	0.227
TotPO4	991	19990	0.199
TotDisPO4	349	7027	0.026
Fecal	43748430	882132800	0.368
DO	7627	153789	0.188

T23

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	141665	13751230	0.075
TotSol	679392	65947650	0.179
DisSol	513982	49891520	0.198
NO2NO3	1210	117418	0.070
NH3N	440	42667	0.122
Orgntr	2071	200992	0.057
TKN	2510	243659	0.057
TotPO4	673	65293	0.113
TotDisPO4	256	24806	0.103
Fecal	18869470	1831633000	0.300
DO	9597	931584	0.122

T24

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	104398	3217457	0.485
TotSol	331248	10208770	0.182
DisSol	221711	6832935	0.065
NO2NO3	1282	39504	0.119
NH3N	403	12428	0.306
Orgntr	1645	50711	0.181
TKN	2049	63140	0.191
TotPO4	702	21630	0.221
TotDisPO4	369	11375	0.069
Fecal	14167810	436640000	0.228
DO	12351	380652	0.236

T25

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	360702	3240293	0.228
TotSol	687023	6171719	0.099
DisSol	316614	2844231	0.040
NO2NO3	3864	34709	0.083
NH3N	450	4042	0.216
Orgntr	2454	22043	0.133
TKN	2779	24964	0.163
TotPO4	1175	10557	0.299
TotDisPO4	221	1985	0.158
Fecal	19077480	171378300	0.322
DO	7849	70511	0.085

T26

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	79075	2604653	0.526
TotSol	286037	9421731	0.131
DisSol	239113	7876128	0.243
NO2NO3	2338	83582	0.265
NH3N	344	11334	0.148
Orgntr	1936	63772	0.054
TKN	2280	75106	0.060
TotPO4	692	22794	0.089
TotDisPO4	496	16334	0.181
Fecal	13965510	460008400	0.22
DO	6328	205464	0.166

T27

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	417718	25789430	0.396
TotSol	660579	40783420	0.258
DisSol	242862	14994000	0.114
NO2NO3	2848	175860	0.269
NH3N	418	25818	0.200
Orgntr	3396	209695	0.278
TKN	3815	235514	0.264
TotPO4	1195	73776	0.274
TotDisPO4	327	20187	0.138
Fecal	2642996	163175600	0.333
DO	6908	426470	0.205

T28

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	114963	6499912	0.336
TotSol	593417	33551430	0.059
DisSol	453170	25621960	0.131
NO2NO3	4465	252454	0.103
NH3N	511	28894	0.342
Orgntr	1945	109974	0.073
TKN	2422	136927	0.091
TotPO4	570	32240	0.159
TotDisPO4	362	20459	0.166
Fecal	7548831	426806300	0.397
DO	7308	413207	0.093

T29

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	79532	8983287	0.223
TotSol	426332	48154770	0.117
DisSol	399871	45165930	0.124
NO2NO3	3174	358561	0.153
NH3N	306	34545	0.455
Orgntr	1742	196756	0.067
TKN	2069	233703	0.049
TotPO4	519	58651	0.095
TotDisPO4	321	36275	0.238
Fecal	8435762	952829600	0.745
DO	8525	962911	0.164

T30

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	198530	26224690	0.467
TotSol	585182	77299400	0.222
DisSol	349548	46173470	0.227
NO2NO3	3455	456443	0.220
NH3N	350	46191	0.424
Orgntr	2325	307079	0.208
TKN	2681	354145	0.213
TotPO4	677	89393	0.287
TotDisPO4	255	33618	0.348
Fecal	7145375	943866000	0.541
DO	7372	973831	0.083

T31

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	377673	140139600	0.433
TotSol	638510	236925700	0.288
DisSol	266017	98708340	0.194
NO2NO3	6234	2313266	0.234
NH3N	567	210336	0.303
Orgntr	3128	1160799	0.288
TKN	3767	1397644	0.238
TotPO4	1153	427851	0.332
TotDisPO4	204	75840	0.210
Fecal	81806660	30355220000	0.768
DO	7854	2914453	0.176

T32

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	567294	29566100	0.327
TotSol	725458	37809260	0.130
DisSol	322440	16804830	0.059
NO2NO3	4970	259003	0.096
NH3N	574	29912	0.205
Orgntr	2696	140510	0.192
TKN	3535	184258	0.144
TotPO4	938	48883	0.221
TotDisPO4	567	29539	0.204
Fecal	5482693	285745700	0.609
DO	9244	481777	0.029

T33

Parameter	Concentration (ppb)	FLUX Load Kg/Yr	CV
SuspSol	299595	37502100	0.288
TotSol	632771	79207840	0.240
DisSol	544515	68160290	0.290
NO2NO3	5117	640512	0.162
NH3N	576	72060	0.252
Orgntr	3185	398743	0.235
TKN	4024	503702	0.252
TotPO4	1048	131137	0.343
TotDisPO4	257	32194	0.091
Fecal	8865	1109652	0.104
DO	10980240	1374465000	0.621

Appendix U
Monthly Concentrations - FLUX

FLUX calculated Monthly Concentrations (parts per billion)

Site	Stream	Year	Month	Complete	SuspSol	TotSol	DisSol	NO2NO3	NH3N	OrgNtr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R01	BSR nr Brookings	1999	7	Y	201493	946383	739808	155	81		2254	462	38	317142	7674
R01	BSR nr Brookings	1999	8	Y	162635	905648	731899	151	61		2066	401	33	237483	8538
R01	BSR nr Brookings	1999	9	Y	184599	928673	736369	153	73		2172	436	36	282509	8050
R01	BSR nr Brookings	1999	10	Y	84758	824008	716048	143	20		1691	279	23	77834	10272
R01	BSR nr Brookings	2000	3	Y	138597	880449	727006	149	48		1950	364	30	188205	9073
R01	BSR nr Brookings	2000	4	Y	84758	824008	716048	143	20		1691	279	23	77834	10272
R01	BSR nr Brookings	2000	5	Y	186305	930462	736716	154	73		2180	438	36	286007	8012
R01	BSR nr Brookings	2000	6	Y	177157	920872	734854	153	69		2136	424	35	267254	8215
R01	BSR nr Brookings	2000	7	Y	134118	875753	726095	148	46		1929	357	30	179023	9173
R01	BSR nr Brookings	2000	8	Y	84758	824008	716048	143	20		1691	279	23	77834	10272
R01	BSR nr Brookings	2000	9	Y	84758	824008	716048	143	20		1691	279	23	77834	10272
R01	BSR nr Brookings	2000	10	Y	84758	824008	716048	143	20		1691	279	23	77834	10272
R01	BSR nr Brookings	2000	11	N	84758	824008	716048	143	20		1691	279	23	77834	10272
R02	BSR @ Sinai Rd	1999	7	Y	177109	800552	656112	271	134	2227	2361	480	117	1113196	7839
R02	BSR @ Sinai Rd	1999	8	Y	144667	834897	667205	210	107	2110	2216	408	88	787401	8189
R02	BSR @ Sinai Rd	1999	9	Y	163004	849380	660935	245	122	2176	2298	449	104	971550	7991
R02	BSR @ Sinai Rd	1999	10	Y	79650	786720	689438	88	51	1875	1926	264	30	134462	8889
R02	BSR @ Sinai Rd	2000	3	Y	124599	844036	674067	172	90	2037	2127	364	70	585862	8405
R02	BSR @ Sinai Rd	2000	4	Y	79650	792335	689438	88	51	1875	1926	264	30	134462	8889
R02	BSR @ Sinai Rd	2000	5	Y	164429	814909	660448	247	123	2181	2305	452	106	985856	7976
R02	BSR @ Sinai Rd	2000	6	Y	156792	821033	663059	233	117	2154	2271	435	99	909160	8058
R02	BSR @ Sinai Rd	2000	7	Y	120859	799847	675346	165	86	2024	2110	355	67	548308	8445
R02	BSR @ Sinai Rd	2000	8	Y	79650	688583	689438	88	51	1875	1926	264	30	134462	8889
R02	BSR @ Sinai Rd	2000	9	Y	79650	625093	689438	88	51	1875	1926	264	30	134462	8889
R02	BSR @ Sinai Rd	2000	10	Y	79650	632346	689438	88	51	1875	1926	264	30	134462	8889
R02	BSR @ Sinai Rd	2000	11	N	79650	711914	689438	88	51	1875	1926	264	30	134462	8889
R03	BSR @ Hwy 77	1999	7	Y	210731	966576	755748	238	119		1960	509	104	316660	7807
R03	BSR @ Hwy 77	1999	8	Y	174950	926386	748843	266	87		2107	474	90	275290	8781
R03	BSR @ Hwy 77	1999	9	Y	195174	949103	752745	250	105		2024	494	98	298673	8231
R03	BSR @ Hwy 77	1999	10	Y	103238	845840	735004	322	22		2402	406	61	192378	10734
R03	BSR @ Hwy 77	2000	3	Y	152815	901524	744571	283	67		2198	453	81	249698	9384
R03	BSR @ Hwy 77	2000	4	Y	103238	845840	735004	322	22		2402	406	61	192378	10734
R03	BSR @ Hwy 77	2000	5	Y	196746	950868	753049	249	107		2017	495	98	300490	8188
R03	BSR @ Hwy 77	2000	6	Y	188322	941406	751423	256	99		2052	487	95	290751	8417
R03	BSR @ Hwy 77	2000	7	Y	148690	896892	743775	286	63		2215	449	79	244929	9497
R03	BSR @ Hwy 77	2000	8	Y	103238	845840	735004	322	22		2402	406	61	192378	10734
R03	BSR @ Hwy 77	2000	9	Y	103238	845840	735004	322	22		2402	406	61	192378	10734
R03	BSR @ Hwy 77	2000	10	Y	103238	845840	735004	322	22		2402	406	61	192378	10734
R03	BSR @ Hwy 77	2000	11	N	103238	845840	735004	322	22		2402	406	61	192378	10734
R04	BSR @ Brookings USGS	1999	7	Y	182620	819986	657896	487	114	2279	2408	498	134	3305742	7435
R04	BSR @ Brookings USGS	1999	8	Y	148547	830248	659201	546	89	2132	2229	461	116	2255534	8316
R04	BSR @ Brookings USGS	1999	9	Y	167806	854045	658464	513	103	2215	2330	482	126	2849145	7818
R04	BSR @ Brookings USGS	1999	10	Y	80260	752918	661817	663	40	1837	1870	386	80	150769	10082
R04	BSR @ Brookings USGS	2000	3	Y	127470	826026	660008	582	74	2041	2118	438	105	1605869	8861
R04	BSR @ Brookings USGS	2000	4	Y	80260	756340	661817	663	40	1837	1870	386	80	150769	10082
R04	BSR @ Brookings USGS	2000	5	Y	169302	825835	658406	510	104	2222	2338	484	127	2895260	7780
R04	BSR @ Brookings USGS	2000	6	Y	161281	826120	658713	524	99	2187	2296	475	123	2648027	7987
R04	BSR @ Brookings USGS	2000	7	Y	123542	790563	660159	589	71	2024	2097	433	103	1484812	8963
R04	BSR @ Brookings USGS	2000	8	Y	80260	691890	661817	663	40	1837	1870	386	80	150769	10082
R04	BSR @ Brookings USGS	2000	9	Y	80260	650876	661817	663	40	1837	1870	386	80	150769	10082
R04	BSR @ Brookings USGS	2000	10	Y	80260	655627	661817	663	40	1837	1870	386	80	150769	10082
R04	BSR @ Brookings USGS	2000	11	N	80260	706773	661817	663	40	1837	1870	386	80	150769	10082
R05	BSR @ Flandreau	1999	7	Y	175333	803783	627682	528	106	2337	2506	556	129	1746708	7486
R05	BSR @ Flandreau	1999	8	Y	145666	758907	621579	457	85	1918	1978	343	100	1200687	8433
R05	BSR @ Flandreau	1999	9	Y	162434	784272	625029	497	97	1950	2011	361	117	1509315	7898
R05	BSR @ Flandreau	1999	10	Y	86209	668970	609349	317	43	1783	1821	265	43	106384	10333
R05	BSR @ Flandreau	2000	3	Y	127313	731147	617804	414	72	1751	1774	266	83	862915	9020
R05	BSR @ Flandreau	2000	4	Y	86209	668970	609349	317	43	1758	1795	258	43	106384	10333
R05	BSR @ Flandreau	2000	5	Y	163737	786243	625297	500	98	2164	2285	467	118	1533291	7856
R05	BSR @ Flandreau	2000	6	Y	154697	772568	623437	479	91	2073	2172	418	109	1366904	8145
R05	BSR @ Flandreau	2000	7	Y	120534	720892	616410	398	67	1945	2006	337	76	738145	9236
R05	BSR @ Flandreau	2000	8	Y	86209	668970	609349	317	43	2283	2355	412	43	106384	10333
R05	BSR @ Flandreau	2000	9	Y	86209	668970	609349	317	43	2716	2822	560	43	106384	10333
R05	BSR @ Flandreau	2000	10	Y	86209	668970	609349	317	43	2674	2776	545	43	106384	10333
R06	BSR @ Egan	1999	7	Y	175008	719314	517685	483	144	2153	2299	421	115	1042022	7510
R06	BSR @ Egan	1999	8	Y	131386	692171	618269	421	112	1974	2087	363	90	1063962	8776
R06	BSR @ Egan	1999	9	Y	123399	687201	618276	410	107	1941	2048	352	85	1067979	9008
R06	BSR @ Egan	1999	10	Y	59858	647664	586508	321	61	1680	1740	267	48	1099936	10853
R06	BSR @ Egan	2000	3	Y	93020	668298	621879	367	85	1816	1901	312	67	1083258	9890
R06	BSR @ Egan	2000	4	Y	59858	647664	597871	321	61	1680	1740	267	48	1099936	10853
R06	BSR @ Egan	2000	5	Y	158511	709049	526029	460	132	2085	2219	399	105	1050319	7989
R06	BSR @ Egan	2000	6	Y	157257	708269	568467	458	131	2080	2213	397	105	1050950	8025
R06	BSR @ Egan	2000	7	Y	98787	671886	617336	376	89	1840	1929	319	71	1080357	9723
R06	BSR @ Egan	2000	8	Y	59858	647664	556326	321	61	1680	1740	267	48	1099936	10853
R06	BSR @ Egan	2000	9	Y	59858	647664	524672	321	61	1680	1740	267	48	1099936	10853
R06	BSR @ Egan	2000	10	Y	59858	647664	522286	321	61	1680	1740	267	48	1099936	10853

R07	BSR @ Trent	1999	7	Y	190711	815714	628344	570	116	2242	2364	465	94	2669991	8166
R07	BSR @ Trent	1999	8	Y	142011	758655	618585	438	86	2082	2172	389	87	2189456	9374
R07	BSR @ Trent	1999	9	Y	133094	748207	616798	413	80	2052	2137	375	86	2101472	9595
R07	BSR @ Trent	1999	10	Y	62156	665095	602583	220	37	1819	1857	264	77	1401517	11353
R07	BSR @ Trent	2000	3	Y	99179	708471	610002	321	60	1941	2003	322	82	1766824	10436
R07	BSR @ Trent	2000	4	Y	62156	665095	602583	220	37	1819	1857	264	77	1401516	11353
R07	BSR @ Trent	2000	5	Y	172294	794136	624654	520	104	2181	2292	436	91	2488267	8623
R07	BSR @ Trent	2000	6	Y	170894	792496	624373	516	103	2177	2286	434	91	2474454	8657
R07	BSR @ Trent	2000	7	Y	105616	716014	611292	339	64	1962	2028	332	82	1830348	10276
R07	BSR @ Trent	2000	8	Y	62156	665095	602583	220	37	1819	1857	264	77	1401517	11353
R07	BSR @ Trent	2000	9	Y	62156	665095	602583	220	37	1819	1857	264	77	1401516	11353
R07	BSR @ Trent	2000	10	Y	62156	665095	602583	220	37	1819	1857	264	77	1401516	11353
R08	BSR @ USGS Dell Rapids	2000	7	Y	106746	831235	719597	674	100	1650	1750	328	181	330617	7678
R08	BSR @ USGS Dell Rapids	2000	8	Y	106746	831236	719597	674	100	1650	1750	328	181	330617	7678
R08	BSR @ USGS Dell Rapids	2000	9	Y	106746	831236	719597	674	100	1650	1750	328	181	330617	7678
R08	BSR @ USGS Dell Rapids	2000	10	Y	106746	831236	719597	674	100	1650	1750	328	181	330617	7678
R08	BSR @ USGS Dell Rapids	2001	4	N	123493	686647	519368	1296	380	1734	2114	573	290	6854479	8904
R08	BSR @ USGS Dell Rapids	2001	5	Y	123493	686647	519368	1296	380	1734	2114	573	290	6854478	8904
R08	BSR @ USGS Dell Rapids	2001	6	Y	123169	689452	523252	1284	375	1733	2107	569	288	6727929	8880
R08	BSR @ USGS Dell Rapids	2001	7	Y	108174	818906	702522	727	124	1657	1781	349	190	886944	7782
R08	BSR @ USGS Dell Rapids	2001	8	Y	106746	831235	719597	674	100	1650	1750	328	181	330617	7678
R08	BSR @ USGS Dell Rapids	2001	9	Y	106746	831235	719597	674	100	1650	1750	328	181	330617	7678
R08	BSR @ USGS Dell Rapids	2001	10	N	106746	831236	719597	674	100	1650	1750	328	181	330617	7678
R09	BSR @ Hwy 38A	2000	7	Y	115861	841790	644678	680	78	1578	1656	379	130	15956220	7826
R09	BSR @ Hwy 38A	2000	8	Y	115861	841791	579883	680	78	1578	1656	379	130	15956220	7769
R09	BSR @ Hwy 38A	2000	9	Y	115861	841791	535007	680	78	1578	1656	379	130	15956220	7726
R09	BSR @ Hwy 38A	2000	10	Y	115861	841790	530871	680	78	1578	1656	379	130	15956220	7722
R09	BSR @ Hwy 38A	2001	4	N	182003	578992	347848	1566	416	1948	2364	721	226	9006296	7896
R09	BSR @ Hwy 38A	2001	5	Y	182003	578992	504831	1566	416	1948	2364	721	226	9006296	9626
R09	BSR @ Hwy 38A	2001	6	Y	180720	584090	609378	1549	409	1941	2350	714	225	9141113	10539
R09	BSR @ Hwy 38A	2001	7	Y	121502	819380	774154	755	107	1610	1717	408	138	15363560	8320
R09	BSR @ Hwy 38A	2001	8	Y	115861	841791	727651	680	78	1578	1656	379	130	15956230	7892
R09	BSR @ Hwy 38A	2001	9	Y	115861	841791	684436	680	78	1578	1656	379	130	15956220	7859
R09	BSR @ Hwy 38A	2001	10	Y	115861	841790	658255	680	78	1578	1656	379	130	15956220	7837
R10	BSR @ Western Ave	2000	7	Y	104502	880852	792448	398	79	1639	1710	283	102	499938	10009
R10	BSR @ Western Ave	2000	8	Y	159859	880852	792448	398	121	1639	1710	433	102	764766	10528
R10	BSR @ Western Ave	2000	9	Y	403834	880852	792448	398	305	1639	1710	1094	102	1931941	11971
R10	BSR @ Western Ave	2000	10	Y	224255	880852	792448	398	169	1639	1710	608	102	1072837	11113
R10	BSR @ Western Ave	2001	4	N	127472	874933	594179	1397	111	1685	1865	304	266	2728944	8496
R10	BSR @ Western Ave	2001	5	Y	217489	874933	594179	1397	190	1685	1865	520	266	4656030	9417
R10	BSR @ Western Ave	2001	6	Y	403820	874933	594179	1397	352	1685	1865	965	266	8645037	10788
R10	BSR @ Western Ave	2001	7	Y	412568	877832	691297	908	302	1663	1789	838	185	7152136	10556
R10	BSR @ Western Ave	2001	8	Y	65947	880852	792448	398	50	1639	1710	179	102	315490	9555
R10	BSR @ Western Ave	2001	9	Y	92496	880852	792448	398	70	1639	1710	251	102	442501	10014
R10	BSR @ Western Ave	2001	10	N	106380	880852	792448	398	80	1639	1710	288	102	508921	10157
R11	BSR @ USGS N. Cliff Ave	2000	7	Y	170950	900621	786673	2613	112	1901	2010	624	424	738968	8930
R11	BSR @ USGS N. Cliff Ave	2000	8	Y	170950	900621	786673	2613	112	1901	2010	624	424	738968	9773
R11	BSR @ USGS N. Cliff Ave	2000	9	Y	170950	900621	786672	2613	112	1901	2010	624	424	738968	11254
R11	BSR @ USGS N. Cliff Ave	2000	10	Y	170950	900621	786672	2613	112	1901	2010	624	424	738968	11270
R11	BSR @ USGS N. Cliff Ave	2001	4	N	190318	684656	407730	1514	360	1945	2308	669	268	8317953	8653
R11	BSR @ USGS N. Cliff Ave	2001	5	N	190318	684656	407730	1514	360	1945	2308	669	268	8317952	11278
R11	BSR @ USGS N. Cliff Ave	2001	6	N	188759	702040	438233	1602	340	1942	2284	665	281	7707892	12387
R11	BSR @ USGS N. Cliff Ave	2001	7	Y	176511	838611	677867	2298	183	1914	2095	637	379	2915106	9292
R11	BSR @ USGS N. Cliff Ave	2001	8	Y	170950	900621	786673	2613	112	1901	2010	624	424	738968	7518
R11	BSR @ USGS N. Cliff Ave	2001	9	Y	170950	900621	786672	2613	112	1901	2010	624	424	738968	8215
R11	BSR @ USGS N. Cliff Ave	2001	10	N	170950	900621	786672	2613	112	1901	2010	624	424	738968	8831
R12	BSR @ Brandon	2000	7	Y	126026	854272	754733	2715	60	2149	2209	813	464	513260	8712
R12	BSR @ Brandon	2000	8	Y	247354	854272	754733	5328	60	2149	2209	1595	464	1007391	8712
R12	BSR @ Brandon	2000	9	Y	617770	854272	754732	13307	60	2149	2209	3983	464	2515972	8712
R12	BSR @ Brandon	2000	10	Y	547168	854272	754732	11786	60	2149	2209	3528	464	2228433	8712
R12	BSR @ Brandon	2001	4	N	87159	825637	599858	480	138	1751	1889	238	215	3553325	9582
R12	BSR @ Brandon	2001	5	Y	154022	825637	599858	848	138	1751	1889	421	215	6279210	9582
R12	BSR @ Brandon	2001	6	Y	236790	825637	599858	1304	138	1751	1889	648	215	9653511	9582
R12	BSR @ Brandon	2001	7	Y	333803	831362	630823	1951	122	1831	1953	939	265	13350620	9408
R12	BSR @ Brandon	2001	8	Y	206476	844571	702264	1643	86	2015	2101	682	380	7260395	9007
R12	BSR @ Brandon	2001	9	Y	71995	854272	754733	1551	60	2149	2209	464	464	293211	8712
R12	BSR @ Brandon	2001	10	N	108093	854272	754732	2328	60	2149	2209	697	464	440227	8712
R13	BSR nr Gitchie Manitou	2000	7	N	226761	850556	755694	2777	133	2047	2103	664	420	479910	9717
R13	BSR nr Gitchie Manitou	2000	8	Y	288472	850556	755695	2777	169	2047	2103	664	420	610515	9717
R13	BSR nr Gitchie Manitou	2000	9	Y	699122	850556	755694	2777	410	2047	2103	664	420	1479603	9717
R13	BSR nr Gitchie Manitou	2000	10	Y	597116	850556	755694	2777	350	2047	2103	664	420	1263722	9717
R13	BSR nr Gitchie Manitou	2001	4	N	258136	1023727	489392	1930	141	3120	3412	1246	214	18688240	8062
R13	BSR nr Gitchie Manitou	2001	5	Y	423810	1023727	489392	1930	232	3120	3412	1246	214	30682530	8062
R13	BSR nr Gitchie Manitou	2001	6	Y	611720	1023727	489392	1930	335	3120	3412	1246	214	44286620	8062
R13	BSR nr Gitchie Manitou	2001	7	Y	971318	1012127	507230	1987	531	3048	3324	1207	228	70134680	8173
R13	BSR nr Gitchie Manitou	2001	8	Y	356762	895456	686648	2557	196	2325	2442	814	367	23422880	9288
R13	BSR nr Gitchie Manitou	2001	9	Y	60753	850556	755695	2777	36	2047	2103	664	420	128576	9717
R13	BSR nr Gitchie Manitou	2001	10	N	304001	885845	701428	2604	169	2266	2369	782	378	18024550	9380
T01	North Deer Creek	1999	8	N	15387	550820	529493	16	96	1077	1172	126	73	685388	6931

T01	North Deer Creek	1999	9	Y	15596	524647	506599	29	103	1070	1172	138	88	585313	6695
T01	North Deer Creek	1999	10	Y	21656	525580	507415	9	103	1070	1172	138	87	558354	6704
T01	North Deer Creek	2000	3	N	16575	547207	526333								
T01	North Deer Creek	2000	4	Y	16874	605461	577290	8	97	1076	1172	128	75	446456	6899
T01	North Deer Creek	2000	5	Y	13989	494382	480125	10	82	1092	1172	101	43	153089	7424
T01	North Deer Creek	2000	6	Y	9832	473491	461850	21	111	1062	1172	152	104	794475	6422
T01	North Deer Creek	2000	7	Y	16040	513416	496774	45	117	1056	1172	161	116	577009	6234
T01	North Deer Creek	2000	8	Y	69522	605461	577290	30	106	1067	1172	143	94	754501	6594
T01	North Deer Creek	2000	9	Y	27055	490194	476461	2	82	1092	1172	101	43	630726	7424
T01	North Deer Creek	2000	10	N	9714	457691	448029	14	112	1061	1172	154	107	1290995	6385
T01	North Deer Creek	2000	11	N				79	121	1052	1172	168	125	672856	6091
T02	North Deer Creek	1999	7	N	8588	518474	539471	433	66	788	881	91	65	250585	11609
T02	North Deer Creek	1999	8	Y	0	0	0	0	0	0	0	0	0	0	0
T02	North Deer Creek	1999	9	Y	8588	518474	549764	276	69	788	908	91	65	250585	11609
T02	North Deer Creek	1999	10	Y	0	0	0	0	0	0	0	0	0	0	0
T02	North Deer Creek	2000	3	N	46715	525997	542728	469	58	1079	811	192	122	5727135	9186
T02	North Deer Creek	2000	4	Y	47084	526070	547980	453	56	1082	795	193	122	5780062	9163
T02	North Deer Creek	2000	5	Y	81103	532783	462654	292	176	1341	1428	283	173	**********	7001
T02	North Deer Creek	2000	6	Y	74716	531522	488043	264	122	1293	1186	266	163	9749211	7407
T02	North Deer Creek	2000	7	Y	67566	530111	468144	348	170	1238	1401	247	153	8722197	7861
T02	North Deer Creek	2000	8	N	8588	518474	576083	92	79	788	978	91	65	250585	11609
T03	Six Mile Creek	1999	7	N	35527	517087	481560	434	174	1321	1476	128	38	749819	16907
T03	Six Mile Creek	2000	3	N	35564	519702	484138	427	176	1362	1519	135	38	733229	18173
T03	Six Mile Creek	2000	4	Y	35980	548760	512780	356	202	1448	1639	155	33	548927	10898
T03	Six Mile Creek	2000	5	Y	35126	489003	453878	502	150	1244	1400	130	43	927941	11516
T03	Six Mile Creek	2000	6	Y	35233	496473	461241	484	156	1271	1447	145	42	880562	9111
T03	Six Mile Creek	2000	7	Y	35231	496386	461155	484	156	1285	1461	147	42	881115	9568
T03	Six Mile Creek	2000	8	Y	36428	580130	543702	279	229	1431	1624	144	27	349960	30934
T03	Six Mile Creek	2000	9	Y	0	0	0	0	0	0	0	0	0	0	0
T03	Six Mile Creek	2000	10	Y	0	0	0	0	0	0	0	0	0	0	0
T03	Six Mile Creek	2000	11	N	36428	580130	543702	279	229	1539	1757	172	27	349960	7689
T04	Six Mile Creek	1999	7	N	65348	593628	520153	737	161	368	1140	207	50	4792495	8597
T04	Six Mile Creek	1999	8	Y	43943	590903	546995	687	189	284	1120	124	32	1723479	9534
T04	Six Mile Creek	1999	9	Y	43943	590903	546995	687	174	316	1203	124	32	1723479	9534
T04	Six Mile Creek	1999	10	Y	43943	590903	546995	687	170	409	1228	124	32	1723479	9534
T04	Six Mile Creek	2000	3	N	64178	593479	521621	734	158	359	1146	203	49	4624727	8648
T04	Six Mile Creek	2000	4	Y	67783	593938	517100	742	156	493	1125	217	52	5141630	8490
T04	Six Mile Creek	2000	5	Y	101599	598243	474694	821	257	2787	2156	348	81	9990059	7010
T04	Six Mile Creek	2000	6	Y	89520	596705	489841	793	186	1010	1379	301	71	8258208	7539
T04	Six Mile Creek	2000	7	Y	90304	596805	488858	795	209	1023	1603	304	71	8370659	7504
T04	Six Mile Creek	2000	8	Y	43943	590903	546995	687	191	273	1115	124	32	1723479	9534
T04	Six Mile Creek	2000	9	Y	43943	590903	546995	687	213	125	1004	124	32	1723479	9534
T04	Six Mile Creek	2000	10	Y	43943	590903	546995	687	202	210	1059	124	32	1723479	9534
T04	Six Mile Creek	2000	11	N	104984	598673	470450	829	182	123	1291	361	84	**********	6862
T05	Six Mile Creek	1999	7	N	63615	459725	399425	372	272	1153	1416	273	116	5294723	7408
T05	Six Mile Creek	1999	8	Y	54818	485498	419526	319	239	1097	1328	241	106	4339287	7660
T05	Six Mile Creek	1999	9	Y	25342	533092	486875	145	128	907	1033	134	73	1138009	8503
T05	Six Mile Creek	1999	10	Y	25342	529690	486875	145	128	907	1033	134	73	1138009	8503
T05	Six Mile Creek	2000	3	N	81585	433374	358365	478	339	1269	1597	338	136	7246385	6894
T05	Six Mile Creek	2000	4	Y	82141	432809	357095	481	341	1272	1602	340	137	7306729	6878
T05	Six Mile Creek	2000	5	Y	86107	443197	348034	505	356	1298	1642	354	142	7737460	6765
T05	Six Mile Creek	2000	6	Y	84834	437064	350943	497	351	1289	1629	350	140	7599174	6801
T05	Six Mile Creek	2000	7	Y	74479	451211	374601	436	313	1223	1525	312	128	6474640	7097
T05	Six Mile Creek	2000	8	Y	59913	475897	407883	350	258	1129	1379	259	112	4892665	7514
T05	Six Mile Creek	2000	9	Y	0	0	0	0	0	0	0	0	0	0	0
T05	Six Mile Creek	2000	10	Y	0	0	0	0	0	0	0	0	0	0	0
T05	Six Mile Creek	2000	11	N	88036	434940	343625	516	363	1310	1661	361	144	7947021	6709
T06	Deer Creek	1999	8	N	14433	723061	678986	333	32	812	844	56	17	1284642	8511
T06	Deer Creek	1999	9	Y	14433	723061	679985	333	32	812	844	56	17	1284642	8516
T06	Deer Creek	1999	10	Y	14433	723061	708256	333	32	812	844	56	17	1284642	8639
T06	Deer Creek	2000	3	N	36547	729609	723057	333	55	921	976	103	27	1200424	9164
T06	Deer Creek	2000	4	Y	81166	742820	683194	333	102	1141	1243	196	48	1030499	9645
T06	Deer Creek	2000	5	Y	128350	756792	629999	333	151	1375	1526	295	69	850804	7708
T06	Deer Creek	2000	6	Y	134097	758493	628911	333	157	1403	1560	307	72	828920	8182
T06	Deer Creek	2000	7	N	127831	756638	636334	333	151	1372	1523	294	69	852781	8415
T06	Deer Creek	2000	8	Y	14433	723061	710411	333	32	812	844	56	17	1284642	8648
T07	Medary Creek	1999	7	N	26198	410112	406640	1995	101	1005	1098	131	51	943301	9353
T07	Medary Creek	1999	8	N	21203	410725	382605	2694	92	1058	1160	112	50	1699189	9330
T07	Medary Creek	1999	9	N	19948	410879	388103	2869	90	1136	1249	108	50	1889164	9324
T07	Medary Creek	1999	10	N	18258	411086	390259	3106	87	1272	1403	102	50	2144870	9316
T07	Medary Creek	2000	3	N	23010	410503	410804	2441	95	1256	1383	119	50	1425810	9338
T07	Medary Creek	2000	4	Y	23371	410459	407116	2390	96	1232	1356	120	51	1371103	9340
T07	Medary Creek	2000	5	Y	28651	409811	363557	1652	105	1320	1464	140	51	572123	9364
T07	Medary Creek	2000	6	Y	28718	409803	380111	1642	105	1087	1193	140	51	561986	9364
T07	Medary Creek	2000	7	Y	18258	411086	395036	3106	87	1365	1509	102	50	2144870	9316
T07	Medary Creek	2000	8	Y	18258	411086	377259	3106	87	1130	1245	102	50	2144869	9316
T07	Medary Creek	2000	9	Y	18258	411086	346047	3106	87	694	754	102	50	2144871	9316
T07	Medary Creek	2000	10	Y	18258	411086	364113	3106	87	909	995	102	50	2144870	9316
T07	Medary Creek	2000	11	N	18258	411086	382578	3106	87	1148	1263	102	50	2144870	9316

T08	Medary Creek	1999	7	N	32654	471051	425527	858	117	951	1036	185	85	1435242	10604
T08	Medary Creek	1999	8	Y	21581	417565	395476	692	80	1162	1228	126	47	703394	9993
T08	Medary Creek	1999	9	N	25463	436318	406012	750	93	1087	1159	147	60	959983	10108
T08	Medary Creek	1999	10	N	21581	417565	395476	692	80	1149	1206	126	47	703395	9340
T08	Medary Creek	2000	3	N	37183	492930	437820	927	131	884	986	208	101	1734601	11319
T08	Medary Creek	2000	4	Y	34619	480543	430860	888	123	932	1025	195	92	1565112	10739
T08	Medary Creek	2000	5	Y	36193	488146	435132	912	128	1258	1416	203	98	798087	8406
T08	Medary Creek	2000	6	Y	37183	492930	437820	927	131	1257	1421	208	101	1734601	8440
T08	Medary Creek	2000	7	Y	29138	454068	415985	806	105	1033	1110	166	73	1202862	9755
T08	Medary Creek	2000	8	Y	21581	417565	395476	692	80	1152	1212	126	47	703395	9512
T08	Medary Creek	2000	9	Y	21581	417565	395476	692	80	1211	1311	126	47	703394	12671
T08	Medary Creek	2000	10	Y	28394	450476	413967	794	103	1078	1170	162	71	1153703	10679
T08	Medary Creek	2000	11	N	30737	461795	420326	830	110	1018	1104	174	79	1308584	10077
T09	Medary Creek	1999	8	N	21119	569316	562224	711	44	737	789	79	32	252174	11393
T09	Medary Creek	1999	9	Y	21119	569316	562224	711	44	737	789	79	32	252174	11393
T09	Medary Creek	1999	10	Y	48093	582159	542817	736	87	910	1048	135	46	878076	10067
T09	Medary Creek	1999	11	N	91364	602761	511685	777	158	1187	1463	224	69	1882117	7940
T09	Medary Creek	2000	3	N	84094	599300	516916	770	146	1141	1394	209	65	1713424	8298
T09	Medary Creek	2000	4	Y	85304	599876	516045	771	148	1148	1405	212	66	1741502	8238
T09	Medary Creek	2000	5	Y	88795	601538	513534	774	153	1171	1439	219	67	1822506	8067
T09	Medary Creek	2000	6	Y	91364	602761	511685	777	158	1187	1463	224	69	1882117	7940
T09	Medary Creek	2000	7	Y	44265	580336	545571	733	81	885	1011	127	44	789244	10255
T09	Medary Creek	2000	8	Y	21119	569316	562224	711	44	737	789	79	32	252174	11393
T09	Medary Creek	2000	9	Y	21119	569316	562224	711	44	737	789	79	32	252174	11393
T09	Medary Creek	2000	10	Y	21119	569316	562224	711	44	737	789	79	32	252174	11393
T10	Lake Cambell Outlet	2000	3	N	63766	1470527	1349976	76	2754	2837	5582	550	132	4302378	6715
T10	Lake Cambell Outlet	2000	4	Y	45394	1388881	1429061	621	1485	2002	3483	321	84	1605295	7597
T10	Lake Cambell Outlet	2000	5	Y	28381	1641726	1502301	1126	309	1229	1539	108	41	36259	8280
T10	Lake Cambell Outlet	2000	6	Y	28298	1590233	1502655	1128	303	1226	1530	107	41	50383	8282
T10	Lake Cambell Outlet	2000	7	Y	32976	1391719	1482518	990	626	1438	2064	166	53	572390	8105
T10	Lake Cambell Outlet	2000	8	Y	30860	1334385	1491629	1052	480	1342	1822	139	47	676129	8200
T10	Lake Cambell Outlet	2000	9	Y	32816	1297297	1483209	994	615	1431	2046	164	52	867043	8125
T10	Lake Cambell Outlet	2000	10	Y	29784	1281497	1496260	1084	406	1293	1699	126	45	826989	8257
T10	Lake Cambell Outlet	2000	11	N	63766	1425011	1349975	76	2754	2837	5582	550	132	2892954	6715
T11	Spring Creek	1999	7	N	23037	482975	470959	2499	113	930	286	100	7437	2510082	9604
T11	Spring Creek	1999	8	Y	15900	480790	512159	3147	81	882	201	94	7310	1119629	10310
T11	Spring Creek	1999	9	N	16088	480848	509806	3117	82	882	203	94	7314	1156145	10291
T11	Spring Creek	1999	10	N	13487	480051	515153	3280	71	865	173	91	7267	649410	10548
T11	Spring Creek	2000	3	N	23387	483082	452688	2346	115	935	290	100	7444	2578254	9570
T11	Spring Creek	2000	4	Y	22023	482664	464978	2481	109	913	274	96	7419	2312441	9704
T11	Spring Creek	2000	5	Y	41613	488660	389969	1595	197	1616	505	271	7768	6129344	7768
T11	Spring Creek	2000	6	Y	45912	489976	427200	1500	216	1459	556	225	7844	6966926	7342
T11	Spring Creek	2000	7	Y	25977	483875	440987	2203	127	996	320	112	7490	3082989	9313
T11	Spring Creek	2000	8	Y	16609	481007	458935	2715	85	892	210	94	7323	1257749	10240
T11	Spring Creek	2000	9	Y	13487	480051	480720	3027	71	871	173	91	7267	649410	10548
T11	Spring Creek	2000	10	Y	21922	482633	465854	2495	108	914	272	97	7417	2292781	9714
T11	Spring Creek	2000	11	N	47639	490505	520585	1657	224	1051	577	118	7875	7303528	7172
T12	Flandreau Creek	1999	8	N	83502	496318	417933	470	174	1166	1341	247	98	3027640	8406
T12	Flandreau Creek	1999	9	Y	90645	498655	414597	501	174	1183	1357	258	101	3260668	8336
T12	Flandreau Creek	1999	10	N	30301	478916	442776	243	171	1039	1223	164	74	1292161	8926
T12	Flandreau Creek	2000	3	N	134257	512920	394232	688	176	1287	1453	326	121	4683332	7910
T12	Flandreau Creek	2000	4	Y	198492	533931	364237	962	179	1440	1595	426	151	6778763	7282
T12	Flandreau Creek	2000	5	Y	229803	544173	349616	1096	181	1515	1664	475	165	7800173	6976
T12	Flandreau Creek	2000	6	Y	218231	540388	355019	1047	180	1487	1638	457	160	7422686	7089
T12	Flandreau Creek	2000	7	Y	48824	484975	434126	322	172	1083	1264	193	82	1896414	8745
T12	Flandreau Creek	2000	8	Y	30301	478916	442776	243	171	1039	1223	164	74	1292160	8926
T12	Flandreau Creek	2000	9	Y	30301	478916	442776	243	171	1039	1223	164	74	1292160	8926
T12	Flandreau Creek	2000	10	Y	30301	478916	442776	243	171	1039	1223	164	74	1292161	8926
T13	Jack Moore Creek	1999	7	N	51251	852778	815063	377	135	1579	1625	333	237		7014
T13	Jack Moore Creek	1999	8	Y	13736	786425	770729	369	221	1424	1641	269	202	1303774	5694
T13	Jack Moore Creek	1999	9	N	13736	789021	773191	364	221	1424	1641	269	202	1303774	5694
T13	Jack Moore Creek	1999	10	N	13736	882720	869288	485	221	1424	1641	269	202	1303774	5694
T13	Jack Moore Creek	2000	3	N	39206	949306	940829	236	163	1529	1631	312	226	8385421	6590
T13	Jack Moore Creek	2000	4	Y	49291	953383	937974	189	140	1571	1626	329	235		6945
T13	Jack Moore Creek	2000	5	Y	55537	773303	719303	1072	125	1596	1624	340	241		7165
T13	Jack Moore Creek	2000	6	Y	49846	884116	852627	305	138	1573	1626	330	236		6965
T13	Jack Moore Creek	2000	7	Y	13736	754800	738189	324	221	1424	1641	269	202	1303774	5694
T13	Jack Moore Creek	2000	8	Y	13736	775943	759792	348	221	1424	1641	269	202	1303773	5694
T13	Jack Moore Creek	2000	9	Y	13736	684401	666438	251	221	1424	1641	269	202	1303774	5694
T13	Jack Moore Creek	2000	10	Y	13736	754925	738343	325	221	1424	1641	269	202	1303774	5694
T13	Jack Moore Creek	2000	11	N	13736	727342	710166	294	221	1424	1641	269	202	1303774	5694
T14	Bachelor Creek	2000	4	N	133971	1103740	923735	1570	261	1991	2210	456	282		8313
T14	Bachelor Creek	2000	5	Y	130966	1099057	923041	1547	260	1971	2190	447	277		8294
T14	Bachelor Creek	2000	6	Y	106109	1060320	917299	1356	249	1810	2024	370	232		8352
T14	Bachelor Creek	2000	7	Y	43872	963333	902922	877	222	1407	1611	179	119	8950388	8471
T14	Bachelor Creek	2000	8	Y	5890	904143	894148	585	205	1161	1358	62	50	787166	8522
T14	Bachelor Creek	2000	9	Y	5890	904144	894148	585	205	1161	1358	62	50	787166	8522
T14	Bachelor Creek	2000	10	Y	5890	904143	894148	585	205	1161	1358	62	50	787166	8522
T14	Bachelor Creek	2000	11	N	5890	904143	894148	585	205	1161	1358	62	50	787166	8522

T15	N. Buffalo Ck	2000	7	N	120690	1350025	1222659	261	153	1525	1658	355	90	4193166	6847
T15	N. Buffalo Ck	2000	8	Y	120690	1350025	1222659	261	153	1525	1658	355	90	3333851	6847
T15	N. Buffalo Ck	2000	9	Y	120690	1350025	1222658	261	153	1525	1658	355	90	1919750	6847
T15	N. Buffalo Ck	2000	10	N	120690	1350025	1222659	261	153	1525	1658	355	90	899566	6847
T15	N. Buffalo Ck	2001	3	N	35606	599290	607921	1176	263	1331	1597	417	333	9100883	9656
T15	N. Buffalo Ck	2001	4	Y	24677	502856	528957	1294	277	1306	1590	425	365	4429121	10017
T15	N. Buffalo Ck	2001	5	Y	41821	654125	652823	1109	255	1345	1602	413	316	8700005	9451
T15	N. Buffalo Ck	2001	6	Y	53646	758460	738257	982	239	1372	1610	404	282	6456497	9061
T15	N. Buffalo Ck	2001	7	Y	120690	1350025	1222659	261	153	1525	1658	355	90	5761458	6847
T15	N. Buffalo Ck	2001	8	Y	120690	1350025	1222659	261	153	1525	1658	355	90	17705100	6847
T15	N. Buffalo Ck	2001	9	Y	120690	1350025	1222658	261	153	1525	1658	355	90	12195330	6847
T15	N. Buffalo Ck	2001	10	N	120690	1350025	1222659	261	153	1525	1658	355	90	10660260	6847
T16	Buffalo Ck	2000	7	N	132812	2245876	2136784	132	670	5612	3198	376	85	561488	8165
T16	Buffalo Ck	2000	8	Y	201858	3413475	3247669	132	904	8530	3198	376	85	853399	8165
T16	Buffalo Ck	2000	9	Y	138169	2336468	2222977	132	719	5838	3198	376	85	584138	8165
T16	Buffalo Ck	2000	10	N	99101	1675817	1594416	132	566	4188	3198	376	85	418969	8165
T16	Buffalo Ck	2001	3	N	194852	1341308	1146456	463	276	4412	2683	525	218	747378	9322
T16	Buffalo Ck	2001	4	Y	92789	638737	545948	463	507	2101	2683	525	218	355905	9322
T16	Buffalo Ck	2001	5	Y	178556	1268270	1090411	413	300	4119	2761	502	197	686402	9146
T16	Buffalo Ck	2001	6	Y	180799	1370480	1191924	358	251	4340	2847	478	175	698400	8955
T16	Buffalo Ck	2001	7	Y	119513	2020988	1922821	132	654	5050	3198	376	85	505265	8165
T16	Buffalo Ck	2001	8	Y	433675	7333543	6977324	132	887	18325	3198	376	85	1833450	8165
T16	Buffalo Ck	2001	9	Y	998207	16879930	16060020	132	936	42180	3198	376	85	4220131	8165
T16	Buffalo Ck	2001	10	N	998207	16879930	16060020	132	936	42180	3198	376	85	4220131	8165
T17	Brant Lake Outlet	2000	7	N	18902	1161175	1117813	342	301	1429	1689	262	115	6887999	10512
T17	Brant Lake Outlet	2000	8	Y	19489	1161175	1117813	342	301	1429	1689	292	115	11364580	10654
T17	Brant Lake Outlet	2000	9	Y	19589	1161175	1117813	342	301	1429	1689	298	115	12154310	10678
T17	Brant Lake Outlet	2000	10	N	19560	1161176	1117813	342	301	1429	1689	296	115	11220920	10671
T17	Brant Lake Outlet	2001	3	N	18619	1161175	1117813	342	301	1429	1689	248	115	5949294	10442
T17	Brant Lake Outlet	2001	4	Y	19812	1256571	1209749	236	421	1501	1953	176	91	4210069	7563
T17	Brant Lake Outlet	2001	5	Y	17887	1256671	1209846	236	421	1501	1953	168	91	4691433	7152
T17	Brant Lake Outlet	2001	6	Y	44103	1271304	1223948	220	439	1512	1993	235	87	2213345	8824
T17	Brant Lake Outlet	2001	7	Y	23349	1271303	1223948	220	439	1512	1993	181	87	4291005	7584
T17	Brant Lake Outlet	2001	8	Y	16260	1181298	1137206	320	326	1444	1744	180	110	2297256	9257
T17	Brant Lake Outlet	2001	9	Y	16383	1177277	1133331	324	321	1441	1733	181	111	2108148	9407
T17	Brant Lake Outlet	2001	10	N	17042	1165181	1121674	338	306	1432	1700	186	114	1434857	9929
T18	Skunk Ck (upper)	2000	7	N	185016	1153975	1040759	235	217	1870	2097	535	78	2156799	10050
T18	Skunk Ck (upper)	2000	8	Y	403714	1153975	1040759	235	217	1870	2097	1168	78	4706248	9922
T18	Skunk Ck (upper)	2000	9	Y	450054	1153975	1040759	235	217	1870	2097	1302	78	5246456	9906
T18	Skunk Ck (upper)	2000	10	N	464520	1153975	1040759	235	217	1870	2097	1344	78	5415094	9907
T18	Skunk Ck (upper)	2001	3	N	109350	764204	712857	619	352	1481	1834	800	218	3676459	8391
T18	Skunk Ck (upper)	2001	4	Y	47898	721357	676811	662	367	1438	1805	357	233	1640869	9572
T18	Skunk Ck (upper)	2001	5	Y	60718	734265	687670	649	362	1451	1814	431	229	1976631	9298
T18	Skunk Ck (upper)	2001	6	Y	107754	837437	774466	547	326	1554	1884	758	192	3471298	8623
T18	Skunk Ck (upper)	2001	7	Y	70445	1153975	1040759	235	217	1870	2097	204	78	821210	10177
T18	Skunk Ck (upper)	2001	8	Y	241531	1153975	1040759	235	217	1870	2097	699	78	2815614	9995
T18	Skunk Ck (upper)	2001	9	Y	283467	1153975	1040759	235	217	1870	2097	820	78	3304484	9970
T18	Skunk Ck (upper)	2001	10	N	260013	1153975	1040759	235	217	1870	2097	752	78	3031075	9983
T19	Colton Ck	2000	7	N	354017	1005897	651881	2250	327	2734	3026	921	304	14709640	7542
T19	Colton Ck	2000	8	Y	354017	1005897	651881	2250	327	2736	3027	921	304	14709640	7542
T19	Colton Ck	2000	9	Y	354017	1005898	651881	2250	327	2728	3015	921	304	14709640	7542
T19	Colton Ck	2000	10	N	354017	1005898	651881	2250	327	2728	3015	921	304	14709640	7542
T19	Colton Ck	2001	3	N	200934	535227	334292	3164	374	2679	3102	1126	609	116757400	8841
T19	Colton Ck	2001	4	Y	200934	535227	334292	3164	374	2468	2875	1126	609	116757400	8841
T19	Colton Ck	2001	5	Y	231578	629444	397866	2981	365	2196	2561	1085	548	96329850	8581
T19	Colton Ck	2001	6	Y	249188	683587	434400	2876	359	2509	2886	1062	513	84590790	8432
T19	Colton Ck	2001	7	Y	298018	833724	535705	2584	344	2384	2696	996	416	52039280	8017
T19	Colton Ck	2001	8	Y	354017	1005897	651881	2250	327	2602	2823	921	304	14709640	7542
T19	Colton Ck	2001	9	Y	354017	1005897	651881	2250	327	2563	2765	921	304	14709640	7542
T19	Colton Ck	2001	10	N	354017	1005897	651880	2250	327	2554	2751	921	304	14709640	7542
T20	W. Branch Skunk Ck	2000	7	N	69340	1143702	1042697	1344	222	1627	1819	338	166	1985712	10192
T20	W. Branch Skunk Ck	2000	8	Y	69340	1141807	1042698	1344	222	1627	1819	338	166	1985711	11192
T20	W. Branch Skunk Ck	2000	9	Y	69340	1138886	1042698	1344	222	1627	1819	338	166	1985712	12864
T20	W. Branch Skunk Ck	2000	10	N	69340	1139487	1042698	1344	222	1627	1819	338	166	1985712	12489
T20	W. Branch Skunk Ck	2001	3	N	83164	421902	540158	1581	644	1844	2519	803	478	44975530	9630
T20	W. Branch Skunk Ck	2001	4	Y	82698	871235	557079	1573	630	1837	2496	787	467	43528070	8188
T20	W. Branch Skunk Ck	2001	5	Y	76615	1451639	778225	1469	444	1741	2188	583	330	24610060	7223
T20	W. Branch Skunk Ck	2001	6	Y	77034	1146935	763004	1476	457	1748	2209	597	340	25912110	7959
T20	W. Branch Skunk Ck	2001	7	Y	73295	1336033	898908	1412	342	1689	2020	471	255	14286190	8596
T20	W. Branch Skunk Ck	2001	8	Y	69340	1141752	1042698	1344	222	1627	1819	338	166	1985713	11182
T20	W. Branch Skunk Ck	2001	9	Y	69340	1141064	1042698	1344	222	1627	1819	338	166	1985712	11563
T20	W. Branch Skunk Ck	2001	10	N	69340	1141315	1042698	1344	222	1627	1819	338	166	1985712	11413
T21	Skunk Ck (middle)	2000	7	N	148011	850424	738445	570	81	1664	1736	326	90	586527	11801
T21	Skunk Ck (middle)	2000	8	Y	182200	850423	738445	570	81	1664	1736	326	90	586527	11801
T21	Skunk Ck (middle)	2000	9	Y	222762	850424	738445	570	81	1664	1736	326	90	586527	11801
T21	Skunk Ck (middle)	2000	10	N	222762	850424	738445	570	81	1664	1736	326	90	586527	11801
T21	Skunk Ck (middle)	2001	3	N	445844	963986	717442	1236	509	2016	2525	804	338	24761620	7725
T21	Skunk Ck (middle)	2001	4	Y	190258	963986	717442	1236	509	2016	2525	804	338	24761620	7725
T21	Skunk Ck (middle)	2001	5	Y	392065	959695	718236	1211	493	2003	2495	786	328	23848070	7879

T21	Skunk Ck (middle)	2001	6	Y	309271	918686	725820	970	338	1875	2210	613	239	15118250	9351
T21	Skunk Ck (middle)	2001	7	Y	133926	860424	736596	629	119	1695	1805	368	112	2715426	11442
T21	Skunk Ck (middle)	2001	8	Y	176810	850424	738445	570	81	1664	1736	326	90	586527	11801
T21	Skunk Ck (middle)	2001	9	Y	224237	850424	738445	570	81	1664	1736	326	90	586527	11801
T21	Skunk Ck (middle)	2001	10	N	231993	850424	738445	570	81	1664	1736	326	90	586527	11801
T22	Willow Ck	2000	7	N	171876	521179	366929	2402	385	2300	2698	710	338	19731490	7956
T22	Willow Ck	2000	8	Y	89144	498919	405694	2703	383	2012	2407	503	330	2089300	8197
T22	Willow Ck	2000	9	Y	89144	498919	405694	2804	383	2012	2407	503	330	2089300	8197
T22	Willow Ck	2000	10	N	89144	498919	405694	2809	383	2012	2407	503	330	2089300	8197
T22	Willow Ck	2001	3	N	307341	557627	303456	2774	386	2771	3175	1049	351	48618400	7560
T22	Willow Ck	2001	4	Y	300653	555827	306590	2509	386	2748	3151	1032	350	47192240	7580
T22	Willow Ck	2001	5	Y	253869	543239	328511	2411	386	2585	2987	915	346	37215780	7716
T22	Willow Ck	2001	6	Y	257943	544335	326602	2524	386	2600	3001	925	346	38084630	7705
T22	Willow Ck	2001	7	Y	281146	550579	315730	2517	386	2680	3083	983	348	43032590	7637
T22	Willow Ck	2001	8	Y	89144	498919	405694	2759	383	2012	2407	503	330	2089299	8197
T22	Willow Ck	2001	9	Y	89144	498919	405694	2805	383	2012	2407	503	330	2089300	8197
T22	Willow Ck	2001	10	N	89144	498919	405694	2803	383	2012	2407	503	330	2089300	8197
T23	Skunk Ck (lower)	2000	7	Y	83636	807540	702494	793	170	1892	2062	366	104	4291504	11009
T23	Skunk Ck (lower)	2000	8	Y	83636	831747	738103	714	120	1858	1978	308	75	1537759	11035
T23	Skunk Ck (lower)	2000	9	Y	83636	831747	738104	714	120	1858	1978	308	75	1537759	11465
T23	Skunk Ck (lower)	2000	10	Y	83636	831747	738104	714	120	1858	1978	308	75	1537759	11172
T23	Skunk Ck (lower)	2001	3	Y	165614	831747	738104	714	120	1858	1978	308	75	1537758	11041
T23	Skunk Ck (lower)	2001	4	Y	176938	640644	456981	1336	521	2125	2646	765	301	23277460	8523
T23	Skunk Ck (lower)	2001	5	Y	172157	640644	456981	1336	521	2125	2646	765	301	23277460	8949
T23	Skunk Ck (lower)	2001	6	Y	140691	645264	463777	1321	511	2118	2629	754	296	22751900	9696
T23	Skunk Ck (lower)	2001	7	Y	119633	745016	610518	996	302	1979	2281	515	178	11404180	10268
T23	Skunk Ck (lower)	2001	8	N	83636	831747	738104	714	120	1858	1978	308	75	1537759	11128
T23	Skunk Ck (lower)	2001	9	Y	83636	831747	738104	714	120	1858	1978	308	75	1537759	11149
T23	Skunk Ck (lower)	2001	10	N	83636	831747	738103	714	120	1858	1978	308	75	1537759	11028
T24	Silver Ck	2001	3	N	0	0	0	0	0	0	0	0	0	0	0
T24	Silver Ck	2001	4	Y	109304	328668	214910	1279	414	1670	2084	718	370	14710280	10666
T24	Silver Ck	2001	5	Y	85249	341318	248256	1293	363	1549	1911	640	367	12050450	22085
T24	Silver Ck	2001	6	Y	104405	331244	221702	1282	403	1645	2049	702	369	14168540	11288
T24	Silver Ck	2001	7	Y	55749	356832	289152	1310	300	1399	1699	545	363	8788435	15219
T24	Silver Ck	2001	8	Y	0	0	0	0	0	0	0	0	0	0	0
T24	Silver Ck	2001	9	Y	0	0	0	0	0	0	0	0	0	0	0
T24	Silver Ck	2001	10	N	0	0	0	0	0	0	0	0	0	0	0
T25	Slip-Up Ck	2000	7	N	43833	553474	527232	5561	85	1744	1313	149	58	2517702	11665
T25	Slip-Up Ck	2000	8	Y	294927	659301	360334	4216	374	2307	2475	962	187	7844070	8641
T25	Slip-Up Ck	2000	9	Y	43833	553474	527232	5561	85	1744	1313	149	58	3962424	11665
T25	Slip-Up Ck	2000	10	Y	43833	553474	527232	5561	85	1744	1313	149	58	3821121	11665
T25	Slip-Up Ck	2001	3	N	443881	722080	261327	3418	546	2640	3164	1445	264	32796600	6848
T25	Slip-Up Ck	2001	4	Y	443881	722080	261327	3418	546	2640	3164	1445	264	30331760	6848
T25	Slip-Up Ck	2001	5	Y	420359	712166	276962	3544	519	2587	3055	1368	252	7445121	7131
T25	Slip-Up Ck	2001	6	Y	354346	684344	320839	3898	443	2440	2750	1155	218	14669210	7926
T25	Slip-Up Ck	2001	7	Y	251674	641071	389083	4448	324	2210	2274	822	165	6913101	9067
T25	Slip-Up Ck	2001	8	Y	43833	553474	527232	5561	85	1744	1313	149	58	1991406	11665
T25	Slip-Up Ck	2001	9	Y	43833	553474	527232	5561	85	1744	1313	149	58	2787525	11665
T25	Slip-Up Ck	2001	10	N	43833	553474	527232	5561	85	1744	1313	149	58	3078334	11665
T26	W. Pipestone Ck (upper)	2000	7	N	102387	419526	370301	3934	332	1936	2268	673	419	39287266	5787
T26	W. Pipestone Ck (upper)	2000	8	Y	2175736	419526	370301	3934	332	1936	2268	673	419	40862038	5787
T26	W. Pipestone Ck (upper)	2000	9	Y	17480600	419526	370301	3934	332	1936	2268	673	419	24147900	5787
T26	W. Pipestone Ck (upper)	2000	10	Y	18063300	419526	370301	3934	332	1936	2268	673	419	1426500	5787
T26	W. Pipestone Ck (upper)	2001	3	N	53008	286022	239388	2651	343	1937	2280	695	507	14431830	6343
T26	W. Pipestone Ck (upper)	2001	4	Y	22281	284854	238243	2640	344	1937	2280	695	507	14214494	6348
T26	W. Pipestone Ck (upper)	2001	5	Y	59405	356065	308071	3324	337	1936	2274	684	461	27516117	6051
T26	W. Pipestone Ck (upper)	2001	6	Y	32087	288296	241618	2673	343	1937	2280	695	505	14858092	6333
T26	W. Pipestone Ck (upper)	2001	7	Y	108402	304114	257129	2825	342	1937	2279	692	495	17813562	6268
T26	W. Pipestone Ck (upper)	2001	8	Y	123268	281999	235443	2613	344	1937	2281	696	509	13680898	6360
T26	W. Pipestone Ck (upper)	2001	9	Y	286446	419526	370301	3934	332	1936	2268	673	419	39391607	5787
T26	W. Pipestone Ck (upper)	2001	10	N	298554	419526	370301	3934	332	1936	2268	673	419	39075136	5787
T27	W. Pipestone Ck (lower)	2000	7	N	294133	620956	326822	2488	294	2548	2842	801	192	20415010	10417
T27	W. Pipestone Ck (lower)	2000	8	Y	323792	630465	306673	2575	324	2752	3076	896	224	21858500	10136
T27	W. Pipestone Ck (lower)	2000	9	Y	245201	605267	360066	2346	245	2213	2457	645	138	18033410	10751
T27	W. Pipestone Ck (lower)	2000	10	Y	245201	605267	360066	2346	245	2213	2457	645	138	18033410	8897
T27	W. Pipestone Ck (lower)	2001	3	N	462098	674809	212710	2978	463	3701	4164	1336	376	28589990	7290
T27	W. Pipestone Ck (lower)	2001	4	Y	457247	673253	216006	2964	458	3668	4126	1321	370	28353870	5577
T27	W. Pipestone Ck (lower)	2001	5	Y	358741	641670	282929	2677	359	2992	3351	1007	262	23559520	8984
T27	W. Pipestone Ck (lower)	2001	6	Y	422381	662074	239694	2862	423	3428	3851	1210	332	26656900	7437
T27	W. Pipestone Ck (lower)	2001	7	Y	356330	640897	284567	2669	356	2975	3332	999	260	23442170	8779
T27	W. Pipestone Ck (lower)	2001	8	Y	245201	605267	360066	2346	245	2213	2457	645	138	18033410	11138
T27	W. Pipestone Ck (lower)	2001	9	Y	245201	605267	360066	2346	245	2213	2457	645	138	18033410	11053
T27	W. Pipestone Ck (lower)	2001	10	N	245201	605267	360066	2346	245	2213	2457	645	138	18033410	9556
T28	Pipestone Ck (upper)	2000	7	N	107555	621137	578999	1181	127	1423	1478	287	187	7759459	8237
T28	Pipestone Ck (upper)	2000	8	Y	132615	615373	578999	852	127	1423	1478	287	187	9567696	8237
T28	Pipestone Ck (upper)	2000	9	Y	198843	610417	578999	641	127	1423	1478	287	187	14345340	8237
T28	Pipestone Ck (upper)	2000	10	Y	155072	612914	578999	742	127	1423	1478	287	187	11187530	8237

T28	Pipestone Ck (upper)	2001	3	N	88678	595249	484199	4631	416	1816	2189	500	319	5843091	7537
T28	Pipestone Ck (upper)	2001	4	Y	93767	505099	421656	4151	607	2076	2658	641	406	6080074	7076
T28	Pipestone Ck (upper)	2001	5	Y	199307	761310	429921	5600	582	2042	2596	623	394	12930710	7137
T28	Pipestone Ck (upper)	2001	6	Y	100227	596044	457210	5345	499	1928	2392	561	356	6534024	7338
T28	Pipestone Ck (upper)	2001	7	Y	62312	691885	568390	5654	160	1467	1557	311	202	4268614	8158
T28	Pipestone Ck (upper)	2001	8	Y	73807	628836	578998	1833	127	1423	1478	287	187	5324749	8237
T28	Pipestone Ck (upper)	2001	9	Y	90444	624017	578999	1384	127	1423	1478	287	187	6525027	8237
T28	Pipestone Ck (upper)	2001	10	N	83555	625721	578999	1512	127	1423	1478	287	187	6027999	8237
T29	Pipestone Ck (lower)	2000	7	N	54045	533591	550327	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2000	8	Y	54045	533591	617258	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2000	9	Y	54045	533591	656423	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2000	10	Y	54045	533591	626187	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2001	3	N	75434	443580	490160	3123	267	1671	1957	479	289	7296856	8689
T29	Pipestone Ck (lower)	2001	4	Y	90719	379256	284252	3316	412	1936	2375	630	409	13603200	8076
T29	Pipestone Ck (lower)	2001	5	Y	81230	419188	604779	3196	322	1771	2116	536	335	8907494	8457
T29	Pipestone Ck (lower)	2001	6	Y	82622	413333	351558	3214	335	1795	2154	550	346	9294178	8401
T29	Pipestone Ck (lower)	2001	7	Y	54045	533591	351384	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2001	8	Y	54045	533591	542588	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2001	9	Y	54045	533591	585826	2852	64	1301	1372	266	120	1353080	9548
T29	Pipestone Ck (lower)	2001	10	N	54045	533591	578989	2852	64	1301	1372	266	120	1353080	9548
T30	Split Rock Ck (upper)	2000	7	N	104498	636741	430788	2758	70	1359	1430	397	59	4210663	8900
T30	Split Rock Ck (upper)	2000	8	Y	79272	483031	430788	2758	70	1359	1430	397	80	3194203	8900
T30	Split Rock Ck (upper)	2000	9	Y	56313	343136	430788	2758	70	1359	1430	397	118	2269103	8900
T30	Split Rock Ck (upper)	2000	10	Y	42752	260501	430788	2758	70	1359	1430	397	162	1722649	8900
T30	Split Rock Ck (upper)	2001	3	N	387065	990623	344494	3499	367	2385	2759	694	285	13725480	7277
T30	Split Rock Ck (upper)	2001	4	Y	155019	388905	321747	3694	445	2655	3109	773	302	5486320	6849
T30	Split Rock Ck (upper)	2001	5	Y	373815	963665	326510	3653	429	2598	3036	756	300	13265150	6939
T30	Split Rock Ck (upper)	2001	6	Y	302449	847761	347266	3475	358	2352	2716	685	258	10825780	7329
T30	Split Rock Ck (upper)	2001	7	Y	107483	654930	430788	2758	70	1359	1430	397	87	4330943	8900
T30	Split Rock Ck (upper)	2001	8	Y	301144	1834973	430788	2758	70	1359	1430	397	26	12134370	8900
T30	Split Rock Ck (upper)	2001	9	Y	310488	1891910	430788	2758	70	1359	1430	397	26	12510890	8900
T30	Split Rock Ck (upper)	2001	10	N	313476	1910117	430788	2758	70	1359	1430	397	26	12631290	8900
T31	Split Rock Ck (lower)	2000	7	N	87471	492985	405926	7782	102	1750	1867	322	31	4025347	8491
T31	Split Rock Ck (lower)	2000	8	Y	87471	492985	405926	5725	102	1750	1867	322	58	2961250	8491
T31	Split Rock Ck (lower)	2000	9	Y	87471	492985	405926	11405	102	1750	1867	322	24	5899725	8491
T31	Split Rock Ck (lower)	2000	10	Y	87471	492985	405926	10440	102	1750	1867	322	25	5400314	8491
T31	Split Rock Ck (lower)	2001	3	N	233968	566445	335298	4372	337	2446	2826	742	173	54090480	8169
T31	Split Rock Ck (lower)	2001	4	Y	401876	650642	254348	5424	606	3243	3925	1222	230	74050780	7801
T31	Split Rock Ck (lower)	2001	5	Y	410955	655194	249971	5996	620	3286	3985	1248	222	82183930	7781
T31	Split Rock Ck (lower)	2001	6	Y	410955	655195	249971	6582	620	3286	3985	1248	214	90204750	7781
T31	Split Rock Ck (lower)	2001	7	Y	404175	651795	253240	7113	609	3254	3940	1229	201	97315940	7796
T31	Split Rock Ck (lower)	2001	8	Y	396581	647987	256901	7688	597	3218	3890	1207	192	########	7813
T31	Split Rock Ck (lower)	2001	9	Y	214861	556864	344510	3856	306	2355	2701	687	167	43510820	8211
T31	Split Rock Ck (lower)	2001	10	N	385723	642542	262136	6129	580	3167	3819	1176	209	82644830	7837
T32	Beaver Ck (upper)	2000	7	N	169233	609649	513370	4826	73	1181	1229	185	109	11522460	10197
T32	Beaver Ck (upper)	2000	8	Y	169233	586141	513370	4826	73	1033	1075	160	133	11522460	10197
T32	Beaver Ck (upper)	2000	9	Y	169233	549456	513370	4826	73	829	864	125	185	11522460	10197
T32	Beaver Ck (upper)	2000	10	Y	169233	568105	513370	4826	73	929	967	142	156	11522460	10197
T32	Beaver Ck (upper)	2001	3	N	758659	703406	230652	5039	815	2822	4110	1129	806	2579152	8786
T32	Beaver Ck (upper)	2001	4	Y	758659	857953	230652	5039	815	3913	5091	1481	596	2579152	8786
T32	Beaver Ck (upper)	2001	5	Y	707695	647194	255096	5020	751	2428	3585	945	990	3352416	8908
T32	Beaver Ck (upper)	2001	6	Y	638196	767992	288432	4995	663	3138	4098	1117	638	4406920	9074
T32	Beaver Ck (upper)	2001	7	Y	513897	692943	348052	4950	507	2412	3171	777	593	6292894	9372
T32	Beaver Ck (upper)	2001	8	Y	200562	658869	498343	4837	112	1620	1745	289	148	11047100	10122
T32	Beaver Ck (upper)	2001	9	Y	169233	625257	513370	4826	73	1290	1341	204	97	11522460	10197
T32	Beaver Ck (upper)	2001	10	N	169233	617822	513370	4826	73	1236	1285	195	102	11522460	10197
T33	Beaver Ck (lower)	2000	7	N	181426	684309	1036688	5160	115	1560	1582	328	99	3459161	9131
T33	Beaver Ck (lower)	2000	8	N	181426	684309	1660586	5160	115	1560	1454	328	99	3459161	9131
T33	Beaver Ck (lower)	2000	9	Y	181426	684309	3823955	5160	115	1560	1258	328	99	3459161	9131
T33	Beaver Ck (lower)	2000	10	Y	181426	684309	2458177	5160	115	1560	1358	328	99	3459161	9131
T33	Beaver Ck (lower)	2001	3	N	325139	621628	932795	5108	675	3537	2732	1203	291	12605900	8807
T33	Beaver Ck (lower)	2001	4	Y	321425	623248	406079	5109	661	3486	4934	1181	286	12369520	8816
T33	Beaver Ck (lower)	2001	5	Y	285199	639048	776476	5122	520	2987	2701	960	238	10063850	8897
T33	Beaver Ck (lower)	2001	6	Y	300744	632269	479040	5116	580	3201	4527	1055	259	11053230	8862
T33	Beaver Ck (lower)	2001	7	Y	265704	647551	482153	5129	444	2719	3070	841	212	8823100	8941
T33	Beaver Ck (lower)	2001	8	Y	181426	684309	366785	5160	115	1560	1959	328	99	3459160	9131
T33	Beaver Ck (lower)	2001	9	Y	181426	684309	774472	5160	115	1560	1676	328	99	3459161	9131
T33	Beaver Ck (lower)	2001	10	N	181426	684309	887616	5160	115	1560	1624	328	99	3459161	9131

Appendix V.
Monthly Loadings - FLUX

Appendix V

FLUX Calculated Monthly Loadings (Kg)															
Site	Stream	Year	Month	Complete	SuspSol	TotSol	DisSol	NO2 NO3	NH3N	Orgntr	TKN	Tot PO4	TotDis PO4	Fecal	DO
R01	BSR nr Brookings	1999	7	Y	5138176	24133290	18865500	3954	2076		57468	11787	977	8087295	195684
R01	BSR nr Brookings	1999	8	Y	2125906	11838320	9567128	1975	797		27009	5245	436	3104291	111612
R01	BSR nr Brookings	1999	9	Y	2462171	12386620	9821672	2045	968		28972	5812	482	3768093	107366
R01	BSR nr Brookings	1999	10	Y	688719	6695667	5818417	1163	163		13738	2268	191	632456	83464
R01	BSR nr Brookings	2000	3	Y	1423710	9044236	7468029	1527	497		20034	3735	311	1933297	93205
R01	BSR nr Brookings	2000	4	Y	705521	6859018	5960364	1191	167		14073	2323	195	647886	85500
R01	BSR nr Brookings	2000	5	Y	3059437	15279730	12098110	2521	1206		35805	7199	598	4696705	131565
R01	BSR nr Brookings	2000	6	Y	2613718	13586240	10841800	2251	1012		31517	6256	520	3942973	121205
R01	BSR nr Brookings	2000	7	Y	1211193	7908765	6557227	1338	415		17418	3220	269	1616719	82841
R01	BSR nr Brookings	2000	8	Y	263913	2565738	2229580	446	62		5264	869	73	242353	31983
R01	BSR nr Brookings	2000	9	Y	120331	1169845	1016574	203	28		2400	396	33	110501	14583
R01	BSR nr Brookings	2000	10	Y	148843	1447043	1257455	251	35		2969	490	41	136684	18038
R01	BSR nr Brookings	2000	11	N	11201	108900	94632	19	3		223	37	3	10286	1358
R02	BSR @ Sinai Rd	1999	7	Y	4516366	21796790	17864100	7381	3651	60642	64290	13066	3180	30309220	213444
R02	BSR @ Sinai Rd	1999	8	Y	1891041	11652460	9312019	2931	1487	29447	30934	5695	1228	10989560	114290
R02	BSR @ Sinai Rd	1999	9	Y	2174145	12096110	9412443	3482	1739	30992	32730	6390	1485	13835950	113805
R02	BSR @ Sinai Rd	1999	10	Y	647217	6825531	5981517	759	446	16265	16711	2292	263	1166585	77124
R02	BSR @ Sinai Rd	2000	3	Y	1279917	9257269	7393075	1888	982	22345	23327	3988	770	6425653	92186
R02	BSR @ Sinai Rd	2000	4	Y	663006	7041952	6127446	778	457	16662	17119	2348	270	1195045	79005
R02	BSR @ Sinai Rd	2000	5	Y	2700193	14288290	11580030	4334	2162	38248	40409	7922	1851	17285610	139847
R02	BSR @ Sinai Rd	2000	6	Y	2313251	12933460	10444950	3668	1841	33928	35767	6851	1556	14321690	126939
R02	BSR @ Sinai Rd	2000	7	Y	1091459	7712372	6511895	1592	833	19514	20346	3427	645	5286952	81433
R02	BSR @ Sinai Rd	2000	8	Y	248009	2289237	2292080	291	171	6233	6404	878	101	447028	29553
R02	BSR @ Sinai Rd	2000	9	Y	113080	947535	1045071	133	78	2842	2920	400	46	203822	13475
R02	BSR @ Sinai Rd	2000	10	Y	139874	1185656	1292704	164	96	3515	3612	495	57	252118	16668
R02	BSR @ Sinai Rd	2000	11	N	10526	100456	97284	12	7	265	272	37	4	18974	1254
R03	BSR @ Hwy 77	1999	7	Y	6278361	28797460	22516180	7101	3549		58388	15158	3101	9434330	232599
R03	BSR @ Hwy 77	1999	8	Y	2671849	14147880	11436420	4063	1327		32178	7246	1369	4204254	134112
R03	BSR @ Hwy 77	1999	9	Y	3041453	14790120	11730230	3902	1638		31537	7696	1524	4654307	128262
R03	BSR @ Hwy 77	1999	10	Y	980104	8030067	6977841	3053	211		22803	3852	577	1826357	101906
R03	BSR @ Hwy 77	2000	3	Y	1834012	10819670	8935991	3399	803		26379	5440	969	2996753	112625
R03	BSR @ Hwy 77	2000	4	Y	1004015	8225971	7148073	3127	216		23359	3946	591	1870913	104393
R03	BSR @ Hwy 77	2000	5	Y	3774773	18243410	14448040	4781	2044		38704	9504	1889	5765221	157095
R03	BSR @ Hwy 77	2000	6	Y	3246161	16227280	12952490	4408	1705		35370	8400	1638	5011754	145092
R03	BSR @ Hwy 77	2000	7	Y	1568839	9463147	7847610	3022	667		23370	4740	834	2584257	100198
R03	BSR @ Hwy 77	2000	8	Y	375570	3077070	2673864	1170	81		8738	1476	221	699848	39050
R03	BSR @ Hwy 77	2000	9	Y	171240	1402986	1219145	533	37		3984	673	101	319095	17805
R03	BSR @ Hwy 77	2000	10	Y	211816	1735428	1508025	660	46		4928	832	125	394706	22024
R03	BSR @ Hwy 77	2000	11	N	15941	130602	113489	50	3		371	63	9	29704	1657
R04	BSR @ Brookings USGS	1999	7	Y	5690475	25550930	20500180	15186	3551	71020	75030	15522	4175	103007600	231690
R04	BSR @ Brookings USGS	1999	8	Y	2372716	13261400	10529310	8720	1428	34056	35600	7359	1855	36027240	132838
R04	BSR @ Brookings USGS	1999	9	Y	2734946	13919430	10731800	8358	1683	36104	37975	7854	2057	46436070	127428
R04	BSR @ Brookings USGS	1999	10	Y	796920	7475859	6571300	6586	399	18243	18566	3830	798	1497010	100108
R04	BSR @ Brookings USGS	2000	3	Y	1600019	10368430	8284541	7307	931	25620	26585	5492	1319	20157150	111231
R04	BSR @ Brookings USGS	2000	4	Y	816362	7693054	6731615	6746	408	18688	19018	3923	818	1533532	102550
R04	BSR @ Brookings USGS	2000	5	Y	3397279	16571490	13211810	10239	2094	44581	46913	9702	2549	58097310	156112
R04	BSR @ Brookings USGS	2000	6	Y	2907600	14893410	11875390	9447	1777	39429	41388	8558	2214	47739040	143995
R04	BSR @ Brookings USGS	2000	7	Y	1363303	8723977	7284950	6498	787	22337	23144	4781	1137	16385110	98908
R04	BSR @ Brookings USGS	2000	8	Y	305375	2632504	2518080	2524	153	6991	7114	1468	306	573645	38361
R04	BSR @ Brookings USGS	2000	9	Y	139235	1129135	1148115	1151	70	3187	3244	669	140	261553	17491
R04	BSR @ Brookings USGS	2000	10	Y	172228	1406882	1420165	1423	86	3943	4012	828	173	323528	21635
R04	BSR @ Brookings USGS	2000	11	N	12961	114137	106877	107	7	297	302	62	13	24348	1628
R05	BSR @ Flandreau	1999	7	Y	5649814	25900620	20226060	16998	3412	75308	80747	17929	4153	56284860	241214
R05	BSR @ Flandreau	1999	8	Y	2406077	12535490	10267140	7556	1405	31688	32673	5666	1659	19832720	139301
R05	BSR @ Flandreau	1999	9	Y	2737724	13218400	10534460	8377	1632	32867	33894	6083	1964	25438520	133111
R05	BSR @ Flandreau	1999	10	Y	885187	6868960	6256774	3255	445	18304	18695	2720	446	1092347	106096
R05	BSR @ Flandreau	2000	3	Y	1652585	9490615	8019381	5375	937	22728	23025	3455	1075	11201030	117079
R05	BSR @ Flandreau	2000	4	Y	906783	7036537	6409416	3335	456	18495	18880	2717	457	1118996	108685
R05	BSR @ Flandreau	2000	5	Y	3397709	16315340	12975550	10378	2028	44912	47416	9693	2444	31817350	163022
R05	BSR @ Flandreau	2000	6	Y	2884051	14403190	11622910	8926	1704	38651	40488	7801	2034	25483560	151847
R05	BSR @ Flandreau	2000	7	Y	1375496	8226580	7034262	4543	770	22197	22897	3850	871	8423463	105401
R05	BSR @ Flandreau	2000	8	Y	339198	2632142	2397556	1247	171	8983	9267	1623	171	418580	40655
R05	BSR @ Flandreau	2000	9	Y	154657	1200122	1093162	569	78	4873	5062	1005	78	190851	18537
R05	BSR @ Flandreau	2000	10	Y	182142	1413401	1287433	670	92	5650	5865	1151	92	224768	21831
R06	BSR @ Egan	1999	7	Y	7141587	29353260	21125330	19701	5869	87862	93800	17178	4689	42522140	306460
R06	BSR @ Egan	1999	8	Y	2410300	12698040	11342290	7731	2060	36211	38290	6655	1645	19518640	161003
R06	BSR @ Egan	1999	9	Y	2182024	12151570	10932790	7253	1884	34323	36222	6226	1504	18884760	159289
R06	BSR @ Egan	1999	10	Y	622358	6733864	6098021	3335	630	17466	18096	2780	502	11436220	112838
R06	BSR @ Egan	2000	3	Y	1454437	10449330	9723521	5745	1322	28397	29727	4872	1054	16937520	154638
R06	BSR @ Egan	2000	4	Y	748579	8099577	7476879	4012	758	21009	21766	3343	603	13755620	135723
R06	BSR @ Egan	2000	5	Y	4603066	20590360	15275570	13346	3830	60556	64428	11585	3060	30500640	231991
R06	BSR @ Egan	2000	6	Y	3889791	17519190	14061160	11324	3240	51453	54728	9827	2588	25995490	198506
R06	BSR @ Egan	2000	7	Y	1334487	9076359	8339448	5073	1199	24855	26061	4313	956	14594300	131341
R06	BSR @ Egan	2000	8	Y	338734	3665081	3148205	1815	343	9507	9849	1513	273	6224457	61415
R06	BSR @ Egan	2000	9	Y	168205	1819964	1474353	901	170	4721	4891	751	136	3090869	30497
R06	BSR @ Egan	2000	10	Y	155213	1679397	1354292	832	157	4356	4513	693	125	2852143	28141

R07	BSR @ Trent	1999	7	Y	8171709	34952250	26923730	24432	4952	96050	101310	19931	4009	114405600	349903
R07	BSR @ Trent	1999	8	Y	2735543	14613930	11915780	8431	1654	40098	41841	7489	1679	42175390	180562
R07	BSR @ Trent	1999	9	Y	2471189	13892180	11452270	7676	1493	38106	39676	6959	1597	39018620	178146
R07	BSR @ Trent	1999	10	Y	678575	7261021	6578562	2407	405	19862	20271	2878	837	15300740	123949
R07	BSR @ Trent	2000	3	Y	1628302	11631600	10014940	5273	980	31866	32885	5280	1339	29007520	171329
R07	BSR @ Trent	2000	4	Y	816199	8733647	7912778	2895	487	23890	24383	3461	1007	18403920	149087
R07	BSR @ Trent	2000	5	Y	5253600	24214850	19046990	15859	3181	66507	69877	13303	2779	75872430	262923
R07	BSR @ Trent	2000	6	Y	4438561	20583170	16216600	13409	2687	56530	59377	11274	2363	64268010	224854
R07	BSR @ Trent	2000	7	Y	1498121	10156330	8670897	4804	903	27831	28772	4705	1169	25962640	145759
R07	BSR @ Trent	2000	8	Y	369332	3951999	3580554	1310	220	10810	11033	1566	456	8327825	67462
R07	BSR @ Trent	2000	9	Y	183399	1962438	1777990	650	110	5368	5479	778	226	4135335	33500
R07	BSR @ Trent	2000	10	Y	169234	1810868	1640665	600	101	4954	5056	718	209	3815939	30912
R08	BSR @ USGS Dell Rapids	2000	7	Y	1544400	12026340	10411150	9755	1446	23874	25319	4747	2618	4783374	111079
R08	BSR @ USGS Dell Rapids	2000	8	Y	646961	5037924	4361310	4086	606	10001	10607	1989	1097	2003791	46532
R08	BSR @ USGS Dell Rapids	2000	9	Y	321261	2501674	2165689	2029	301	4966	5267	988	545	995020	23106
R08	BSR @ USGS Dell Rapids	2000	10	Y	310552	2418285	2093499	1962	291	4801	5091	955	527	961852	22336
R08	BSR @ USGS Dell Rapids	2001	4	N	52758130	293345200	221881300	553826	#####	740946	903327	244985	124072	2928332000	3803839
R08	BSR @ USGS Dell Rapids	2001	5	Y	27237220	151444100	114549700	285921	83832	382525	466357	126478	64054	1511797000	1963792
R08	BSR @ USGS Dell Rapids	2001	6	Y	18332390	102617900	77880780	191155	55764	257900	313664	84644	42910	1001384000	1321703
R08	BSR @ USGS Dell Rapids	2001	7	Y	7449204	56392480	48377960	50082	8527	114126	122653	24036	13105	61077820	535903
R08	BSR @ USGS Dell Rapids	2001	8	Y	4421379	34429540	29805510	27926	4139	68346	72486	13591	7496	13694060	318003
R08	BSR @ USGS Dell Rapids	2001	9	Y	2627022	20456780	17709350	16593	2459	40609	43068	8075	4454	8136510	188946
R08	BSR @ USGS Dell Rapids	2001	10	N	1884728	14676490	12705370	11904	1764	29134	30899	5793	3195	5837448	135557
R09	BSR @ Hwy 38A	2000	7	Y	1689654	12276170	9401607	9912	1139	23017	24156	5528	1890	232696000	114127
R09	BSR @ Hwy 38A	2000	8	Y	707808	5142582	3542561	4152	477	9642	10119	2316	792	97478120	47461
R09	BSR @ Hwy 38A	2000	9	Y	351475	2553643	1622990	2062	237	4788	5025	1150	393	48404550	23438
R09	BSR @ Hwy 38A	2000	10	Y	339760	2468522	1556760	1993	229	4628	4857	1112	380	46791070	22644
R09	BSR @ Hwy 38A	2001	4	N	78374140	249326300	149790800	674347	#####	838925	######	310337	97494	3878301000	3400305
R09	BSR @ Hwy 38A	2001	5	Y	40461880	128718600	112231400	348142	92486	433109	525595	160216	50333	2002234000	2139972
R09	BSR @ Hwy 38A	2001	6	Y	27112770	87629180	91423060	232361	61430	291202	352632	107126	33685	1371412000	1581196
R09	BSR @ Hwy 38A	2001	7	Y	8433717	56875140	53735870	52425	7423	111742	119165	28335	9570	1066421000	577503
R09	BSR @ Hwy 38A	2001	8	Y	4837216	35144780	30379430	28377	3262	65894	69155	15827	5412	666172700	329474
R09	BSR @ Hwy 38A	2001	9	Y	2874097	20881740	16978360	16861	1938	39152	41090	9404	3216	395815500	194941
R09	BSR @ Hwy 38A	2001	10	N	2061989	14981370	11714990	12096	1390	28089	29479	6747	2307	283973400	139482
R10	BSR @ Western Ave	2000	7	Y	376906	3176957	2858110	1437	285	5913	6167	1021	366	1803119	36099
R10	BSR @ Western Ave	2000	8	Y	376906	2076819	1868385	940	285	3865	4031	1021	240	1803119	24821
R10	BSR @ Western Ave	2000	9	Y	364748	795597	715749	360	275	1481	1544	988	92	1744954	10812
R10	BSR @ Western Ave	2000	10	Y	376906	1480450	1331869	670	285	2755	2874	1021	171	1803119	18678
R10	BSR @ Western Ave	2001	4	Y	459740	3155524	2142960	5037	401	6079	6728	1098	959	9842179	30641
R10	BSR @ Western Ave	2001	5	Y	14251930	57333940	38936280	91520	12427	110444	122244	34043	17429	305107500	617097
R10	BSR @ Western Ave	2001	6	Y	13792190	29882730	20293780	47701	12026	57564	63714	32945	9084	295265300	368461
R10	BSR @ Western Ave	2001	7	Y	5747883	12229920	9631120	12646	4202	23167	24927	11673	2584	99643230	147060
R10	BSR @ Western Ave	2001	8	Y	376906	5034338	4529081	2278	285	9370	9772	1021	581	1803119	54607
R10	BSR @ Western Ave	2001	9	Y	364748	3473541	3124929	1571	275	6465	6742	988	401	1744954	39489
R10	BSR @ Western Ave	2001	10	N	364748	3020203	2717090	1366	275	5621	5862	988	348	1744954	34827
R11	BSR @ USGS N. Cliff Ave	2000	7	Y	2885733	15203010	13279500	44116	1891	32088	33923	10528	7157	12474220	150746
R11	BSR @ USGS N. Cliff Ave	2000	8	Y	1470264	7745845	6765825	22477	964	16349	17284	5364	3646	6355541	84057
R11	BSR @ USGS N. Cliff Ave	2000	9	Y	569701	3001377	2621637	8710	373	6335	6697	2078	1413	2462659	37505
R11	BSR @ USGS N. Cliff Ave	2000	10	Y	664651	3501607	3058577	10161	436	7391	7813	2425	1648	2873102	43818
R11	BSR @ USGS N. Cliff Ave	2001	4	N	100692400	362234700	215719800	800928	#####	######	######	353856	141869	4400824000	4578292
R11	BSR @ USGS N. Cliff Ave	2001	5	N	49729170	178897700	106538000	395556	94079	508324	603014	174760	70065	2173445000	2946972
R11	BSR @ USGS N. Cliff Ave	2001	6	N	31041470	115450900	72067590	263506	55927	319332	375569	109390	46159	1267567000	2037124
R11	BSR @ USGS N. Cliff Ave	2001	7	Y	15538100	73822250	59672090	202266	16131	168457	184439	56043	33382	256614300	817936
R11	BSR @ USGS N. Cliff Ave	2001	8	Y	8814053	46435400	40560310	134747	5776	98007	103612	32156	21859	38100700	387617
R11	BSR @ USGS N. Cliff Ave	2001	9	Y	4894746	25787170	22524520	74830	3208	54427	57540	17857	12139	21158620	235228
R11	BSR @ USGS N. Cliff Ave	2001	10	N	3171839	16710310	14596090	48490	2079	35269	37286	11572	7866	13710970	163857
R12	BSR @ Brandon	2000	7	Y	2155391	14610460	12908050	46426	1020	36762	37781	13896	7941	8778189	148998
R12	BSR @ Brandon	2000	8	Y	2155391	7443944	6576578	46426	520	18730	19249	13896	4046	8778189	75914
R12	BSR @ Brandon	2000	9	Y	2085862	2884396	2548306	44929	201	7258	7459	13448	1568	8495022	29415
R12	BSR @ Brandon	2000	10	Y	2155391	3365128	2973024	46426	235	8467	8702	13896	1829	8778189	34318
R12	BSR @ Brandon	2001	4	N	1322351	12526280	9100841	7282	2091	26572	28662	3617	3259	53909820	145378
R12	BSR @ Brandon	2001	5	Y	40992870	219742400	159651600	225725	36678	466130	502809	112129	57177	1671205000	2550290
R12	BSR @ Brandon	2001	6	Y	39670520	138322700	100496900	218444	23088	293418	316506	108512	35991	1617295000	1605348
R12	BSR @ Brandon	2001	7	Y	29717470	74013580	56160170	173671	10877	163006	173883	83610	23566	1188564000	837582
R12	BSR @ Brandon	2001	8	Y	10925150	44688270	37158440	86913	4556	106597	111153	36078	20096	384164800	476569
R12	BSR @ Brandon	2001	9	Y	2085862	24750320	21866420	44929	1727	62275	64002	13448	13452	8495022	252405
R12	BSR @ Brandon	2001	10	N	2085862	16484810	14564010	44929	1150	41478	42628	13448	8960	8495022	168113
R13	BSR nr Gitchie Manitou	2000	7	N	1465921	5498516	4885271	17951	860	13234	13594	4290	2716	3102434	62816
R13	BSR nr Gitchie Manitou	2000	8	Y	3495655	10306890	9157370	33648	2052	24806	25481	8041	5091	7398115	117748
R13	BSR nr Gitchie Manitou	2000	9	Y	3382892	4115650	3656635	13436	1985	9905	10175	3211	2033	7159466	47018
R13	BSR nr Gitchie Manitou	2000	10	Y	3495655	4979350	4424008	16256	2052	11984	12310	3885	2460	7398115	56885
R13	BSR nr Gitchie Manitou	2001	4	N	4427427	17558490	8393828	33108	2421	53517	58516	21366	3678	320532100	138278
R13	BSR nr Gitchie Manitou	2001	5	Y	137250200	331532400	158488900	625129	75059	######	######	403425	69445	9936495000	2610909
R13	BSR nr Gitchie Manitou	2001	6	Y	132822800	222282000	106261800	419129	72638	677493	740783	270484	46561	9615962000	1750531
R13	BSR nr Gitchie Manitou	2001	7	Y	124306200	129528800	64913700	254291	67994	390116	425398	154433	29206	8975613000	1045951
R13	BSR nr Gitchie Manitou	2001	8	Y	29383660	73751590	56553710	210623	16182	191519	201139	67083	30210	1929157000	764966
R13	BSR nr Gitchie Manitou	2001	9	Y	3382892	47361310	42079150	154617	1985	113987	117087	36948	23394	7159466	541063
R13	BSR nr Gitchie Manitou	2001	10	N	16326880	47575800	37671380	139866	9051	121687	127257	42008	20312	968039900	503752
T01	North Deer Creek	1999	8	N	2099	75145	72236	70	13	147	160	17	10	93504	946

T01	North Deer Creek	1999	9	Y	3925	132029	127487	74	26	269	295	35	22	147296	1685
T01	North Deer Creek	1999	10	Y	3342	81105	78302	74	16	165	181	21	13	86163	1035
T01	North Deer Creek	2000	3	N	2084	68807	66182	71	12	135	147	16	9	56138	868
T01	North Deer Creek	2000	4	Y	2587	92806	88488	62	13	167	180	16	7	23466	1138
T01	North Deer Creek	2000	5	Y	6241	220573	214211	78	50	474	523	68	47	354461	2865
T01	North Deer Creek	2000	6	Y	6378	307163	299611	81	76	685	760	105	75	374317	4044
T01	North Deer Creek	2000	7	Y	4903	156938	151851	75	33	326	358	44	29	230631	2016
T01	North Deer Creek	2000	8	Y	2673	23277	22194	62	3	42	45	4	2	24248	285
T01	North Deer Creek	2000	9	Y	4817	87274	84829	79	20	189	209	27	19	229849	1137
T01	North Deer Creek	2000	10	Y	9278	437120	427893	83	116	1005	1119	161	119	642615	5818
T02	North Deer Creek	1999	7	N	1547	93376	97157	78	12	142	159	17	12	45130	2091
T02	North Deer Creek	1999	8	Y	0	0	0	0	0	0	0	0	0	0	0
T02	North Deer Creek	1999	9	Y	151	9112	9661	5	1	14	16	2	1	4404	204
T02	North Deer Creek	1999	10	Y	0	0	0	0	0	0	0	0	0	0	0
T02	North Deer Creek	2000	3	N	22135	249232	257159	222	28	511	384	91	58	2713675	4353
T02	North Deer Creek	2000	4	Y	28933	323274	336738	279	35	665	488	119	75	3551889	5631
T02	North Deer Creek	2000	5	Y	159985	1050977	912639	577	347	2646	2818	558	341	21041110	13810
T02	North Deer Creek	2000	6	Y	94218	670255	615426	333	154	1630	1496	336	206	12293850	9340
T02	North Deer Creek	2000	7	Y	52072	408543	360786	268	131	954	1080	191	118	6721970	6058
T02	North Deer Creek	2000	8	N	26	1586	1762	0	0	2	3	0	0	766	36
T03	Six Mile Creek	1999	7	N	3316	48263	44947	41	16	123	138	12	4	69986	1578
T03	Six Mile Creek	2000	3	N	1129	16492	15364	14	6	43	48	4	1	23268	577
T03	Six Mile Creek	2000	4	Y	5900	89993	84092	58	33	238	269	25	5	90020	1787
T03	Six Mile Creek	2000	5	Y	13202	183790	170588	189	56	468	526	49	16	348764	4328
T03	Six Mile Creek	2000	6	Y	12302	173357	161055	169	55	444	505	51	15	307472	3181
T03	Six Mile Creek	2000	7	Y	14911	210083	195172	205	66	544	619	62	18	372909	4050
T03	Six Mile Creek	2000	8	Y	1157	18424	17267	9	7	45	52	5	1	11114	982
T03	Six Mile Creek	2000	9	Y	0	0	0	0	0	0	0	0	0	0	0
T03	Six Mile Creek	2000	10	Y	0	0	0	0	0	0	0	0	0	0	0
T03	Six Mile Creek	2000	11	N	450	7173	6723	4	3	19	22	2	0	4327	95
T04	Six Mile Creek	1999	7	N	24486	222431	194900	276	60	0	427	78	19	1795735	3221
T04	Six Mile Creek	1999	8	Y	12934	173927	161003	202	56	0	330	37	9	507289	2806
T04	Six Mile Creek	1999	9	Y	13339	179368	166040	208	53	0	365	38	10	523159	2894
T04	Six Mile Creek	1999	10	Y	16890	227125	210249	264	66	0	472	48	12	662453	3664
T04	Six Mile Creek	2000	3	N	23365	216068	189907	267	57	0	417	74	18	1683728	3149
T04	Six Mile Creek	2000	4	Y	34499	302295	263187	378	79	1	572	110	27	2616925	4321
T04	Six Mile Creek	2000	5	Y	148170	872465	692285	1198	376	1	3145	508	118	14569310	10223
T04	Six Mile Creek	2000	6	Y	75689	504513	414160	671	158	1	1166	255	60	6982306	6374
T04	Six Mile Creek	2000	7	Y	65989	436109	357228	581	153	1	1171	222	52	6116771	5484
T04	Six Mile Creek	2000	8	Y	12502	168121	155629	195	54	0	317	35	9	490357	2713
T04	Six Mile Creek	2000	9	Y	6352	85418	79071	99	31	0	145	18	5	249138	1378
T04	Six Mile Creek	2000	10	Y	10140	136353	126221	158	47	0	244	29	7	397699	2200
T04	Six Mile Creek	2000	11	N	11587	66075	51923	92	20	0	143	40	9	1156140	757
T05	Six Mile Creek	1999	7	N	19614	141746	123154	115	84	356	437	84	36	1632509	2284
T05	Six Mile Creek	1999	8	Y	1715	15188	13124	10	8	34	42	8	3	135745	240
T05	Six Mile Creek	1999	9	Y	1609	33855	30920	9	8	58	66	9	5	72272	540
T05	Six Mile Creek	1999	10	Y	2836	59273	54482	16	14	102	116	15	8	127346	952
T05	Six Mile Creek	2000	3	N	33114	175900	145455	194	138	515	648	137	55	2941198	2798
T05	Six Mile Creek	2000	4	Y	44531	234639	193593	261	185	690	869	184	74	3961209	3729
T05	Six Mile Creek	2000	5	Y	145190	747300	586840	851	601	2188	2769	597	239	13046590	11406
T05	Six Mile Creek	2000	6	Y	76091	392024	314777	446	315	1157	1461	314	126	6816057	6100
T05	Six Mile Creek	2000	7	Y	46636	282531	234561	273	196	766	955	195	80	4054172	4444
T05	Six Mile Creek	2000	8	Y	2027	16101	13800	12	9	38	47	9	4	165530	254
T05	Six Mile Creek	2000	9	Y	0	0	0	0	0	0	0	0	0	0	0
T05	Six Mile Creek	2000	10	N	0	0	0	0	0	0	0	0	0	0	0
T06	Deer Creek	1999	8	N	113	5649	5305	3	0	6	7	0	0	10037	67
T06	Deer Creek	1999	9	Y	709	35533	33416	16	2	40	42	3	1	63130	419
T06	Deer Creek	1999	10	Y	1597	80005	78367	37	4	90	93	6	2	142143	956
T06	Deer Creek	2000	3	N	6194	123651	122541	56	9	156	165	17	5	203444	1553
T06	Deer Creek	2000	4	Y	27244	249333	229319	112	34	383	417	66	16	345894	3237
T06	Deer Creek	2000	5	Y	182940	1078667	897947	474	216	1959	2175	421	99	1212664	10986
T06	Deer Creek	2000	6	Y	171680	971074	805174	426	201	1796	1998	393	92	1061239	10476
T06	Deer Creek	2000	7	N	103967	615386	517541	271	123	1116	1238	239	56	693581	6844
T06	Deer Creek	2000	8	Y	1406	70456	69223	32	3	79	82	6	2	125177	843
T07	Medary Creek	1999	7	N	8453	132318	131198	644	32	324	354	42	16	304345	3018
T07	Medary Creek	1999	8	N	2311	44772	41707	294	10	115	127	12	6	185223	1017
T07	Medary Creek	1999	9	N	2418	49807	47046	348	11	138	151	13	6	229005	1130
T07	Medary Creek	1999	10	N	2722	61292	58187	463	13	190	209	15	7	319797	1389
T07	Medary Creek	2000	3	N	6049	107912	107991	642	25	330	364	31	13	374815	2455
T07	Medary Creek	2000	4	Y	8832	155119	153856	903	36	466	512	46	19	518162	3530
T07	Medary Creek	2000	5	Y	45064	644577	571825	2598	165	2076	2302	220	81	899872	14728
T07	Medary Creek	2000	6	Y	32027	457024	423912	1831	117	1212	1330	156	57	626743	10443
T07	Medary Creek	2000	7	Y	3178	71547	68754	541	15	238	263	18	9	373302	1622
T07	Medary Creek	2000	8	Y	1397	31454	28866	238	7	87	95	8	4	164116	713
T07	Medary Creek	2000	9	Y	454	10214	8598	77	2	17	19	3	1	53290	232
T07	Medary Creek	2000	10	Y	1040	23418	20742	177	5	52	57	6	3	122184	531
T07	Medary Creek	2000	11	N	231	5208	4847	39	1	15	16	1	1	27173	118
T08	Medary Creek	1999	7	N	15051	217126	196142	396	54	438	478	85	39	661557	4888
T08	Medary Creek	1999	8	Y	2820	54566	51679	90	11	152	161	17	6	91917	1306

T08	Medary Creek	1999	9	N	5619	96279	89591	166	21	240	256	32	13	211832	2230
T08	Medary Creek	1999	10	N	6095	117925	111687	195	23	325	341	36	13	198647	2638
T08	Medary Creek	2000	3	N	22987	304738	270668	573	81	546	609	129	63	1072362	6998
T08	Medary Creek	2000	4	Y	28766	399307	358023	738	102	774	852	162	77	1300528	8924
T08	Medary Creek	2000	5	Y	72816	982098	875440	1834	258	2531	2848	409	197	3358148	16913
T08	Medary Creek	2000	6	Y	88326	1170915	1040006	2201	312	2986	3376	495	240	4120404	20049
T08	Medary Creek	2000	7	Y	19304	300828	275597	534	70	684	735	110	49	796915	6463
T08	Medary Creek	2000	8	Y	5183	100286	94980	166	19	277	291	30	11	168932	2284
T08	Medary Creek	2000	9	Y	655	12673	12002	21	2	37	40	4	1	21347	385
T08	Medary Creek	2000	10	Y	2465	39102	35933	69	9	94	102	14	6	100143	927
T08	Medary Creek	2000	11	N	1803	27090	24658	49	7	60	65	10	5	76766	591
T09	Medary Creek	1999	8	N	4971	134001	132332	167	10	173	186	19	7	59355	2682
T09	Medary Creek	1999	9	Y	13251	357210	352760	446	27	462	495	49	20	158223	7148
T09	Medary Creek	1999	10	Y	46937	568165	529769	718	85	888	1023	131	45	856969	9825
T09	Medary Creek	1999	11	N	27431	180971	153627	233	47	356	439	67	21	565081	2384
T09	Medary Creek	2000	3	N	70988	505897	436353	650	123	963	1176	177	55	1446382	7005
T09	Medary Creek	2000	4	Y	129511	910751	783477	1171	224	1743	2134	322	100	2644006	12508
T09	Medary Creek	2000	5	Y	303731	2057616	1756588	2649	525	4005	4922	749	231	6234048	27593
T09	Medary Creek	2000	6	Y	340754	2248073	1908394	2897	588	4428	5458	837	257	7019592	29615
T09	Medary Creek	2000	7	Y	53668	703618	661468	888	98	1073	1226	154	53	956905	12434
T09	Medary Creek	2000	8	Y	9130	246134	243068	307	19	318	341	34	14	109023	4925
T09	Medary Creek	2000	9	Y	4333	116812	115357	146	9	151	162	16	7	51741	2338
T09	Medary Creek	2000	10	Y	3198	86212	85138	108	7	112	120	12	5	38187	1725
T10	Lake Cambell Outlet	2000	3	N	163	3750	3442	0	7	7	14	1	0	10971	17
T10	Lake Cambell Outlet	2000	4	Y	1808	55323	56923	25	59	80	139	13	3	63943	303
T10	Lake Cambell Outlet	2000	5	Y	47346	2738773	2506180	1878	515	2051	2567	181	68	60488	13812
T10	Lake Cambell Outlet	2000	6	Y	29256	1644027	1553487	1166	313	1267	1581	111	42	52088	8562
T10	Lake Cambell Outlet	2000	7	Y	3048	128638	137030	92	58	133	191	15	5	52906	749
T10	Lake Cambell Outlet	2000	8	Y	2709	117147	130951	92	42	118	160	12	4	59358	720
T10	Lake Cambell Outlet	2000	9	Y	2164	85530	97787	66	41	94	135	11	3	57164	536
T10	Lake Cambell Outlet	2000	10	Y	2056	88479	103307	75	28	89	117	9	3	57098	570
T10	Lake Cambell Outlet	2000	11	N	145	3243	3072	0	6	7	13	1	0	6583	15
T11	Spring Creek	1999	7	N	9055	189848	185125	982	45	365	112	39	2924	986663	3775
T11	Spring Creek	1999	8	Y	6943	209938	223635	1374	36	385	88	41	3192	488888	4502
T11	Spring Creek	1999	9	N	6020	179939	190775	1167	31	330	76	35	2737	432643	3851
T11	Spring Creek	1999	10	N	5594	199097	213654	1360	29	359	72	38	3014	269336	4375
T11	Spring Creek	2000	3	N	10829	223679	209606	1086	53	433	134	46	3447	1193796	4431
T11	Spring Creek	2000	4	Y	12906	282853	272488	1454	64	535	160	57	4348	1355147	5687
T11	Spring Creek	2000	5	Y	55678	653824	521776	2134	263	2162	676	363	10393	8201020	10393
T11	Spring Creek	2000	6	Y	58857	628123	547647	1923	277	1870	713	288	10056	8931219	9413
T11	Spring Creek	2000	7	Y	18788	349962	318943	1593	92	720	232	81	5417	2229766	6736
T11	Spring Creek	2000	8	Y	9422	272872	260351	1540	48	506	119	53	4154	713512	5809
T11	Spring Creek	2000	9	Y	6587	234471	234797	1479	35	426	84	45	3550	317191	5152
T11	Spring Creek	2000	10	Y	13265	292045	281892	1510	66	553	165	59	4488	1387380	5878
T11	Spring Creek	2000	11	N	3838	39518	41942	134	18	85	46	10	635	588418	578
T12	Flandreau Creek	1999	8	N	12857	76419	64350	72	27	180	206	38	15	466168	1294
T12	Flandreau Creek	1999	9	Y	59804	328990	273533	331	115	780	895	170	67	2151242	5500
T12	Flandreau Creek	1999	10	N	18333	289757	267891	147	104	629	740	99	45	781792	5401
T12	Flandreau Creek	2000	3	N	37335	142636	109630	191	49	358	404	91	34	1302368	2200
T12	Flandreau Creek	2000	4	Y	223654	601615	410409	1084	202	1622	1797	480	170	7638068	8205
T12	Flandreau Creek	2000	5	Y	653351	1547134	993989	3117	514	4306	4731	1349	470	22176610	19832
T12	Flandreau Creek	2000	6	Y	488446	1209499	794605	2343	404	3328	3667	1022	358	16613490	15866
T12	Flandreau Creek	2000	7	Y	20982	208414	186562	138	74	466	543	83	35	814969	3758
T12	Flandreau Creek	2000	8	Y	5700	90089	83291	46	32	196	230	31	14	243070	1679
T12	Flandreau Creek	2000	9	Y	64	1008	932	1	0	2	3	0	0	2719	19
T12	Flandreau Creek	2000	10	Y	4201	66395	61385	34	24	144	170	23	10	179141	1238
T13	Jack Moore Creek	1999	7	N	11636	193617	185054	86	31	358	369	76	54	2664139	1593
T13	Jack Moore Creek	1999	8	Y	207	11834	11598	6	3	21	25	4	3	19619	86
T13	Jack Moore Creek	1999	9	N	316	18140	17776	8	5	33	38	6	5	29975	131
T13	Jack Moore Creek	1999	10	N	1260	81002	79769	45	20	131	151	25	19	119640	523
T13	Jack Moore Creek	2000	3	N	3325	80502	79784	20	14	130	138	27	19	711095	559
T13	Jack Moore Creek	2000	4	Y	10628	205566	202243	41	30	339	351	71	51	2412606	1498
T13	Jack Moore Creek	2000	5	Y	63569	885138	823329	1227	143	1827	1859	389	276	14795320	8202
T13	Jack Moore Creek	2000	6	Y	12939	229500	221326	79	36	408	422	86	61	2944620	1808
T13	Jack Moore Creek	2000	7	Y	83	4582	4482	2	1	9	10	2	1	7915	35
T13	Jack Moore Creek	2000	8	Y	122	6876	6733	3	2	13	15	2	2	11553	51
T13	Jack Moore Creek	2000	9	Y	51	2530	2464	1	1	5	6	1	1	4819	21
T13	Jack Moore Creek	2000	10	Y	139	7621	7454	3	2	14	17	3	2	13162	58
T13	Jack Moore Creek	2000	11	N	33	1764	1722	1	1	4	4	1	1	3162	14
T14	Bachelor Creek	2000	4	N	18749	154467	129275	220	37	279	309	64	40	3962621	1163
T14	Bachelor Creek	2000	5	Y	245813	2062839	1732471	2904	488	3700	4110	838	520	51932520	15566
T14	Bachelor Creek	2000	6	Y	58930	588874	509444	753	138	1005	1124	206	129	12399600	4639
T14	Bachelor Creek	2000	7	Y	8470	185971	174309	169	43	272	311	35	23	1727867	1635
T14	Bachelor Creek	2000	8	Y	301	46133	45623	30	11	59	69	3	3	40164	435
T14	Bachelor Creek	2000	9	Y	89	13723	13571	9	3	18	21	1	1	11948	129
T14	Bachelor Creek	2000	10	Y	172	26340	26048	17	6	34	40	2	2	22932	248
T14	Bachelor Creek	2000	11	N	51	7815	7729	5	2	10	12	1	0	6804	74
T15	N. Buffalo Ck	2000	7	N	31522	352607	319340	68	40	398	433	93	24	1095193	1788
T15	N. Buffalo Ck	2000	8	Y	42382	474078	429352	92	54	536	582	125	32	1170723	2405

T15	N. Buffalo Ck	2000	9	Y	71226	796729	721563	154	90	900	978	210	53	1132958	4041
T15	N. Buffalo Ck	2000	10	N	152003	1700288	1539876	329	192	1921	2088	448	114	1132958	8624
T15	N. Buffalo Ck	2001	3	N	53663	903211	916219	1773	396	2006	2407	629	502	13716270	14553
T15	N. Buffalo Ck	2001	4	Y	323008	6582114	6923754	16936	3621	17099	20807	5563	4772	57974760	131119
T15	N. Buffalo Ck	2001	5	Y	160463	2509817	2504819	4257	977	5162	6146	1583	1211	33381090	36263
T15	N. Buffalo Ck	2001	6	Y	135356	1913715	1862740	2479	604	3463	4063	1019	711	16290770	22862
T15	N. Buffalo Ck	2001	7	Y	24524	274324	248443	53	31	310	337	72	18	1170723	1391
T15	N. Buffalo Ck	2001	8	Y	7980	89268	80846	17	10	101	110	24	6	1170723	453
T15	N. Buffalo Ck	2001	9	Y	11212	125419	113586	24	14	142	154	33	8	1132958	636
T15	N. Buffalo Ck	2001	10	N	12827	143479	129942	28	16	162	176	38	10	1132958	728
T16	Buffalo Ck	2000	7	N	28076	474770	451709	28	142	1186	676	80	18	118697	1726
T16	Buffalo Ck	2000	8	Y	36265	613245	583457	24	162	1532	575	68	15	153317	1467
T16	Buffalo Ck	2000	9	Y	35095	593463	564636	33	183	1483	812	96	22	148371	2074
T16	Buffalo Ck	2000	10	N	33925	573680	545815	45	194	1434	1095	129	29	143425	2795
T16	Buffalo Ck	2001	3	N	517213	3560357	3043144	1229	732	11710	7121	1393	578	1983833	24745
T16	Buffalo Ck	2001	4	Y	1293033	8900893	7607862	6452	7060	29275	37386	7315	3032	4959582	129906
T16	Buffalo Ck	2001	5	Y	749096	5320788	4574614	1731	1258	17281	11584	2107	828	2879669	38372
T16	Buffalo Ck	2001	6	Y	370545	2808776	2442830	733	515	8894	5834	979	359	1431360	18352
T16	Buffalo Ck	2001	7	Y	36265	613245	583457	40	199	1532	971	114	26	153317	2478
T16	Buffalo Ck	2001	8	Y	36265	613245	583457	11	74	1532	267	31	7	153317	683
T16	Buffalo Ck	2001	9	Y	35095	593463	564636	5	33	1483	112	13	3	148371	287
T16	Buffalo Ck	2001	10	N	35095	593463	564636	5	33	1483	112	13	3	148371	287
T17	Brant Lake Outlet	2000	7	N	32812	2015620	1940349	594	522	2481	2931	455	200	11956500	18247
T17	Brant Lake Outlet	2000	8	Y	21918	1305907	1257139	385	338	1607	1899	329	129	12781080	11982
T17	Brant Lake Outlet	2000	9	Y	19935	1181665	1137538	348	306	1454	1719	303	117	12368790	10867
T17	Brant Lake Outlet	2000	10	N	21562	1279961	1232162	377	332	1575	1862	326	127	12368790	11763
T17	Brant Lake Outlet	2001	3	N	10322	643766	619726	190	167	792	936	138	64	3298343	5789
T17	Brant Lake Outlet	2001	4	Y	299251	18979780	18272560	3566	6354	22669	29494	2658	1372	63590670	114229
T17	Brant Lake Outlet	2001	5	Y	261784	18391480	17706190	3454	6158	21965	28582	2461	1329	68659490	104676
T17	Brant Lake Outlet	2001	6	Y	1638262	47223780	45464710	8161	16314	56160	74048	8726	3234	82216810	327788
T17	Brant Lake Outlet	2001	7	Y	462284	25170470	24232870	4350	8696	29933	39468	3590	1724	84957370	150157
T17	Brant Lake Outlet	2001	8	Y	172864	12558520	12089780	3400	3467	15354	18545	1908	1168	24422400	98408
T17	Brant Lake Outlet	2001	9	Y	168493	12108040	11656060	3335	3302	14823	17827	1857	1140	21681850	96752
T17	Brant Lake Outlet	2001	10	N	174563	11934810	11489160	3459	3132	14670	17411	1904	1167	14697060	101701
T18	Skunk Ck (upper)	2000	7	N	150085	936106	844265	191	176	1517	1701	434	63	1749598	8152
T18	Skunk Ck (upper)	2000	8	Y	160436	458589	413597	94	86	743	834	464	31	1870260	3943
T18	Skunk Ck (upper)	2000	9	Y	155260	398100	359042	81	75	645	724	449	27	1809929	3417
T18	Skunk Ck (upper)	2000	10	N	155260	385702	347861	79	73	625	701	449	26	1809929	3311
T18	Skunk Ck (upper)	2001	3	N	551358	3853220	3594319	3123	1774	7467	9249	4036	1099	18537190	42310
T18	Skunk Ck (upper)	2001	4	Y	1786107	26899100	25237980	24669	13674	53625	67325	13303	8699	61187310	356943
T18	Skunk Ck (upper)	2001	5	Y	1030221	12458540	11667940	11009	6146	24619	30782	7320	3880	33538200	157760
T18	Skunk Ck (upper)	2001	6	Y	916322	7121438	6585935	4654	2776	13215	16019	6448	1629	29519380	73329
T18	Skunk Ck (upper)	2001	7	Y	160436	2628116	2370272	536	494	4259	4777	464	177	1870260	23178
T18	Skunk Ck (upper)	2001	8	Y	160436	766523	691320	156	144	1242	1393	464	52	1870260	6639
T18	Skunk Ck (upper)	2001	9	Y	155260	632054	570043	129	119	1024	1149	449	43	1809929	5461
T18	Skunk Ck (upper)	2001	10	N	155260	689067	621462	141	130	1117	1252	449	46	1809929	5961
T19	Colton Ck	2000	7	N	65795	186947	121153	418	61	508	562	171	57	2733805	1402
T19	Colton Ck	2000	8	Y	143642	408142	264500	913	133	1110	1228	374	123	5968420	3060
T19	Colton Ck	2000	9	Y	149893	425903	276010	953	138	1155	1277	390	129	6228140	3193
T19	Colton Ck	2000	10	N	149893	425903	276010	953	138	1155	1277	390	129	6228140	3193
T19	Colton Ck	2001	3	N	1022044	2722409	1700364	16092	1902	13628	15779	5729	3098	593881700	44969
T19	Colton Ck	2001	4	Y	1607787	4282649	2674860	25314	2993	19747	23001	9012	4873	934241300	70742
T19	Colton Ck	2001	5	Y	688780	1872150	1183370	8866	1084	6532	7616	3228	1630	286513300	25522
T19	Colton Ck	2001	6	Y	590820	1620776	1029956	6818	852	5949	6842	2517	1216	200563600	19991
T19	Colton Ck	2001	7	Y	189890	531228	341338	1647	219	1519	1718	635	265	33158140	5108
T19	Colton Ck	2001	8	Y	28278	80348	52070	180	26	208	226	74	24	1174964	602
T19	Colton Ck	2001	9	Y	9185	26098	16913	58	9	67	72	24	8	381645	196
T19	Colton Ck	2001	10	N	14449	41055	26606	92	13	104	112	38	12	600366	308
T20	W. Branch Skunk Ck	2000	7	N	36410	600554	547517	706	116	854	955	178	87	1042691	5352
T20	W. Branch Skunk Ck	2000	8	Y	24245	399236	364582	470	78	569	636	118	58	694309	3913
T20	W. Branch Skunk Ck	2000	9	Y	12411	203848	186631	241	40	291	326	61	30	355420	2303
T20	W. Branch Skunk Ck	2000	10	N	14479	237939	217728	281	46	340	380	71	35	414642	2608
T20	W. Branch Skunk Ck	2001	3	N	1274321	6464826	8276880	24229	9867	28262	38602	12303	7317	689163000	147561
T20	W. Branch Skunk Ck	2001	4	Y	879560	9266276	5924974	16733	6698	19539	26543	8373	4967	462955400	87084
T20	W. Branch Skunk Ck	2001	5	Y	217578	4122491	2210071	4172	1260	4945	6213	1655	938	69889780	20512
T20	W. Branch Skunk Ck	2001	6	Y	185818	2766602	1840496	3561	1102	4216	5328	1440	819	62504410	19198
T20	W. Branch Skunk Ck	2001	7	Y	72057	1313471	883728	1388	337	1661	1985	463	251	14044940	8451
T20	W. Branch Skunk Ck	2001	8	Y	26058	429072	391847	505	83	611	684	127	63	746234	4202
T20	W. Branch Skunk Ck	2001	9	Y	21350	351332	321046	414	68	501	560	104	51	611399	3560
T20	W. Branch Skunk Ck	2001	10	N	23152	381074	348147	449	74	543	607	113	56	663011	3811
T21	Skunk Ck (middle)	2000	7	N	383332	2202506	1912493	1477	211	4309	4496	844	234	1519041	30563
T21	Skunk Ck (middle)	2000	8	Y	409768	1912602	1660762	1283	183	3741	3904	733	203	1319098	26540
T21	Skunk Ck (middle)	2000	9	Y	396550	1513884	1314545	1016	145	2961	3090	580	161	1044107	21007
T21	Skunk Ck (middle)	2000	10	N	396550	1513884	1314545	1016	145	2961	3090	580	161	1044107	21007
T21	Skunk Ck (middle)	2001	3	N	5684660	12291140	9147623	15756	6487	25704	32192	10253	4305	315718800	98495
T21	Skunk Ck (middle)	2001	4	Y	14211650	72006470	53590480	92307	38005	150587	188592	60067	25219	1849609000	577022
T21	Skunk Ck (middle)	2001	5	Y	13303860	32565100	24371730	41079	16717	67956	84661	26673	11139	809231000	267353
T21	Skunk Ck (middle)	2001	6	Y	5462088	16225100	12818850	17138	5975	33122	39034	10832	4220	267006400	165145
T21	Skunk Ck (middle)	2001	7	Y	870272	5591183	4786524	4088	773	11012	11732	2390	728	17645300	74351

T21	Skunk Ck (middle)	2000	8	Y	409768	1912602	1660762	1283	183	3741	3904	733	203	1319098	26540
T21	Skunk Ck (middle)	2000	9	Y	396550	1513884	1314545	1016	145	2961	3090	580	161	1044107	21007
T21	Skunk Ck (middle)	2000	10	N	396550	1513884	1314545	1016	145	2961	3090	580	161	1044107	21007
T21	Skunk Ck (middle)	2001	3	N	5684660	12291140	9147623	15756	6487	25704	32192	10253	4305	315718800	98495
T21	Skunk Ck (middle)	2001	4	Y	14211650	72006470	53590480	92307	38005	150587	188592	60067	25219	1849609000	577022
T21	Skunk Ck (middle)	2001	5	Y	13303860	32565100	24371730	41079	16717	67956	84661	26673	11139	809231000	267353
T21	Skunk Ck (middle)	2001	6	Y	5462088	16225100	12818850	17138	5975	33122	39034	10832	4220	267006400	165145
T21	Skunk Ck (middle)	2001	7	Y	870272	5591183	4786524	4088	773	11012	11732	2390	728	17645300	74351
T21	Skunk Ck (middle)	2001	8	Y	409768	1970913	1711396	1322	189	3856	4023	755	209	1359314	27349
T21	Skunk Ck (middle)	2001	9	Y	396550	1503924	1305896	1009	144	2942	3070	576	160	1037237	20869
T21	Skunk Ck (middle)	2001	10	N	396550	1453645	1262238	975	139	2844	2967	557	154	1002561	20171
T22	Willow Ck	2000	7	N	46291	140366	98823	647	104	620	727	191	91	5314175	2143
T22	Willow Ck	2000	8	Y	15577	87181	70891	472	67	352	421	88	58	365085	1432
T22	Willow Ck	2000	9	Y	5177	28972	23558	163	22	117	140	29	19	121324	476
T22	Willow Ck	2000	10	N	4901	27429	22304	154	21	111	132	28	18	114865	451
T22	Willow Ck	2001	3	N	1947759	3533931	1923138	17582	2449	17563	20120	6645	2222	308116700	47913
T22	Willow Ck	2001	4	Y	1898288	3509427	1935772	15844	2440	17351	19896	6515	2210	297966300	47858
T22	Willow Ck	2001	5	Y	554540	1186628	717585	5266	843	5647	6524	1998	755	81292570	16855
T22	Willow Ck	2001	6	Y	451524	952848	571710	4419	675	4550	5253	1619	606	66666380	13487
T22	Willow Ck	2001	7	Y	349484	684407	392473	3129	480	3332	3832	1222	433	53492440	9493
T22	Willow Ck	2001	8	Y	8945	50061	40707	277	39	202	242	50	33	209637	823
T22	Willow Ck	2001	9	Y	5167	28921	23517	163	22	117	140	29	19	121112	475
T22	Willow Ck	2001	10	N	5309	29712	24160	167	23	120	143	30	20	124423	488
T23	Skunk Ck (lower)	2000	7	Y	179328	1731484	1506250	1699	366	4056	4422	784	223	9201610	23606
T23	Skunk Ck (lower)	2000	8	Y	145951	1451457	1288042	1246	209	3242	3451	537	131	2683497	19257
T23	Skunk Ck (lower)	2000	9	Y	50096	498201	442110	428	72	1113	1185	184	45	921088	6867
T23	Skunk Ck (lower)	2000	10	Y	115971	1153310	1023463	990	166	2576	2742	427	104	2132274	15492
T23	Skunk Ck (lower)	2001	3	Y	2158440	1196658	1061931	1027	172	2673	2845	443	108	2212417	15885
T23	Skunk Ck (lower)	2001	4	Y	17928740	1583214	1129331	3301	1287	5251	6538	1892	745	57525240	21064
T23	Skunk Ck (lower)	2001	5	Y	7275192	27726620	19777820	57810	22545	91955	114500	33128	13046	1007432000	387294
T23	Skunk Ck (lower)	2001	6	Y	2837260	12343390	8871694	25264	9779	40520	50300	14431	5662	435226100	185476
T23	Skunk Ck (lower)	2001	7	Y	883139	5193494	4255910	6944	2104	13796	15900	3593	1240	79498330	71575
T23	Skunk Ck (lower)	2001	8	N	164123	1271144	1128031	1091	183	2840	3022	470	115	2350129	17007
T23	Skunk Ck (lower)	2001	9	Y	108174	1210700	1074392	1039	174	2705	2879	448	109	2238380	16228
T23	Skunk Ck (lower)	2001	10	N	115623	1622001	1439386	1392	233	3623	3857	600	146	2998804	21507
T24	Silver Ck	2001	3	N	0	0	0	0	0	0	0	0	0	0	495
T24	Silver Ck	2001	4	Y	1289419	3877174	2535213	15088	4880	19704	24584	8466	4361	173531900	125820
T24	Silver Ck	2001	5	Y	171398	686239	499133	2599	729	3113	3842	1287	738	24228130	44403
T24	Silver Ck	2001	6	Y	498953	1583028	1059519	6126	1927	7864	9791	3354	1764	67711940	53945
T24	Silver Ck	2001	7	Y	22237	142331	115335	522	120	558	678	217	145	3505485	6070
T24	Silver Ck	2001	8	Y	0	0	0	0	0	0	0	0	0	0	1279
T24	Silver Ck	2001	9	Y	0	0	0	0	0	0	0	0	0	0	1237
T24	Silver Ck	2001	10	N	0	0	0	0	0	0	0	0	0	0	1237
T25	Slip-Up Ck	2000	7	N	3710	46840	44619	471	7	148	111	13	5	213080	987
T25	Slip-Up Ck	2000	8	Y	129413	289299	158113	1850	164	1012	1086	422	82	3441820	3792
T25	Slip-Up Ck	2000	9	Y	5107	64489	61431	648	10	203	153	17	7	461702	1359
T25	Slip-Up Ck	2000	10	Y	5470	69066	65792	694	11	218	164	19	7	476843	1456
T25	Slip-Up Ck	2001	3	N	643201	1046321	378672	4953	791	3826	4584	2093	382	47520110	9922
T25	Slip-Up Ck	2001	4	Y	1054910	1716066	621058	8124	1297	6274	7519	3433	627	72079860	16274
T25	Slip-Up Ck	2001	5	Y	504466	854659	332377	4253	622	3105	3666	1642	302	8934405	8558
T25	Slip-Up Ck	2001	6	Y	393536	760032	356324	4329	492	2709	3054	1282	242	16290540	8802
T25	Slip-Up Ck	2001	7	Y	181731	462910	280952	3212	234	1596	1642	594	119	4991652	6616
T25	Slip-Up Ck	2001	8	Y	10365	130882	124676	1315	20	413	311	35	14	470934	2758
T25	Slip-Up Ck	2001	9	Y	6870	86746	82633	872	13	273	206	23	9	436907	1828
T25	Slip-Up Ck	2001	10	N	6540	82577	78662	830	13	260	196	22	9	459300	1740
T26	W. Pipestone Ck (upper)	2000	7	N	15733	64463	56900	605	51	297	348	104	64	6050239	889
T26	W. Pipestone Ck (upper)	2000	8	Y	18063	3483	3074	33	3	16	19	6	4	326896	48
T26	W. Pipestone Ck (upper)	2000	9	Y	17481	257	227	2	0	1	1	0	0	24148	4
T26	W. Pipestone Ck (upper)	2000	10	Y	18063	15	13	0	0	0	0	0	0	1427	0
T26	W. Pipestone Ck (upper)	2001	3	N	177252	956422	800484	8865	1149	6477	7625	2324	1694	48260040	21210
T26	W. Pipestone Ck (upper)	2001	4	Y	340975	4359202	3645899	40401	5258	29640	34897	10637	7763	217524400	97141
T26	W. Pipestone Ck (upper)	2001	5	Y	69141	414425	358565	3869	393	2254	2646	796	536	32028760	7043
T26	W. Pipestone Ck (upper)	2001	6	Y	170715	1533824	1285482	14222	1826	10304	12131	3695	2687	79045050	33696
T26	W. Pipestone Ck (upper)	2001	7	Y	137245	385032	325545	3577	433	2452	2885	876	626	22551970	7935
T26	W. Pipestone Ck (upper)	2001	8	Y	546452	1250116	1043732	11582	1524	8586	10110	3084	2257	60647420	28193
T26	W. Pipestone Ck (upper)	2001	9	Y	17481	25602	22598	240	20	118	138	41	26	2402888	353
T26	W. Pipestone Ck (upper)	2001	10	N	17481	24564	21682	230	19	113	133	39	25	2305433	339
T27	W. Pipestone Ck (lower)	2000	7	N	230669	486974	256305	1951	230	1999	2229	628	150	16010120	8170
T27	W. Pipestone Ck (lower)	2000	8	Y	304254	592421	288168	2419	304	2586	2890	842	211	20539520	9524
T27	W. Pipestone Ck (lower)	2000	9	Y	178422	440427	262005	1707	178	1610	1788	470	100	13122150	7823
T27	W. Pipestone Ck (lower)	2000	10	Y	537588	1327012	789424	5142	536	4851	5387	1415	302	39537180	19505
T27	W. Pipestone Ck (lower)	2001	3	N	3088441	4510093	1421652	19902	3094	24736	27830	8931	2510	191081600	48724
T27	W. Pipestone Ck (lower)	2001	4	Y	14128660	20803120	6674465	91576	14151	113332	127483	40814	11442	876117600	172333
T27	W. Pipestone Ck (lower)	2001	5	Y	1448096	2590169	1142073	10804	1449	12077	13525	4065	1059	95100440	36265
T27	W. Pipestone Ck (lower)	2001	6	Y	2778542	4355315	1576774	18827	2782	22554	25335	7959	2185	175356700	48922
T27	W. Pipestone Ck (lower)	2001	7	Y	847645	1524579	676934	6350	848	7078	7925	2378	618	55764680	20883
T27	W. Pipestone Ck (lower)	2001	8	Y	157991	389994	232003	1511	158	1426	1583	416	89	11619550	7176
T27	W. Pipestone Ck (lower)	2001	9	Y	159239	393076	233836	1523	159	1437	1596	419	90	11711350	7178
T27	W. Pipestone Ck (lower)	2001	10	N	358860	885829	526970	3433	358	3238	3596	945	202	26392530	13986
T28	Pipestone Ck (upper)	2000	7	N	68331	394613	367821	750	81	904	939	183	119	4929642	5233
T28	Pipestone Ck (upper)	2000	8	Y	78454	364047	342509	504	75	842	874	170	111	5659960	4873
T28	Pipestone Ck (upper)	2000	9	Y	75923	233071	221062	245	49	543	564	110	71	5477381	3145
T28	Pipestone Ck (upper)	2000	10	Y	78454	310083	292908	376	65	720	748	145	95	5659960	4167
T28	Pipestone Ck (upper)	2001	3	N	176235	1182969	962246	9203	828	3610	4350	995	633	11612280	14979
T28	Pipestone Ck (upper)	2001	4	Y	2263910	12195100	10180470	100210	14658	50118	64180	15478	9794	146797300	170839

T28	Pipestone Ck (upper)	2001	5	Y	2047642	7821561	4416913	57538	5979	20974	26673	6396	4049	132847800	73322
T28	Pipestone Ck (upper)	2001	6	Y	951118	5656229	4338674	50720	4733	18299	22694	5325	3380	62005350	69636
T28	Pipestone Ck (upper)	2001	7	Y	151387	1680939	1380830	13737	388	3565	3784	756	490	10370620	19821
T28	Pipestone Ck (upper)	2001	8	Y	78454	668424	615448	1948	136	1513	1571	305	199	5659960	8755
T28	Pipestone Ck (upper)	2001	9	Y	75923	523826	486036	1162	107	1195	1241	241	157	5477381	6914
T28	Pipestone Ck (upper)	2001	10	N	75923	568566	526111	1374	116	1293	1343	261	170	5477381	7484
T29	Pipestone Ck (lower)	2000	7	N	138472	1367155	1410034	7309	164	3333	3515	682	308	3466830	24463
T29	Pipestone Ck (lower)	2000	8	Y	147198	1453314	1681195	7769	174	3543	3736	725	327	3685314	26005
T29	Pipestone Ck (lower)	2000	9	Y	133951	1322520	1626963	7070	158	3224	3400	660	298	3353645	23665
T29	Pipestone Ck (lower)	2000	10	Y	145100	1432593	1681195	7658	171	3492	3683	714	323	3632768	25634
T29	Pipestone Ck (lower)	2001	3	N	232348	1366292	1509765	9618	822	5147	6028	1474	890	22475400	26765
T29	Pipestone Ck (lower)	2001	4	Y	4453850	18619570	13955320	162789	20230	95030	116606	30949	20098	566770000	396496
T29	Pipestone Ck (lower)	2001	5	Y	1084404	5596077	8073678	42665	4298	23647	28242	7157	4466	118913200	112898
T29	Pipestone Ck (lower)	2001	6	Y	1348145	6744394	5736417	52435	5469	29296	35140	8974	5638	151654100	137081
T29	Pipestone Ck (lower)	2001	7	Y	258576	2552961	1681195	13648	305	6223	6563	1273	575	6473799	45681
T29	Pipestone Ck (lower)	2001	8	Y	167456	1653318	1681195	8838	198	4030	4250	824	372	4192482	29584
T29	Pipestone Ck (lower)	2001	9	Y	150093	1481895	1626963	7922	177	3612	3810	739	334	3757788	26516
T29	Pipestone Ck (lower)	2001	10	N	151866	1499393	1626963	8016	179	3655	3855	748	338	3802161	26829
T30	Split Rock Ck (upper)	2000	7	N	132520	807490	546308	3498	89	1724	1813	503	74	5339792	11287
T30	Split Rock Ck (upper)	2000	8	Y	342343	2086014	1860400	11912	303	5871	6174	1713	346	13794470	38436
T30	Split Rock Ck (upper)	2000	9	Y	331300	2018723	2534395	16227	413	7998	8411	2333	696	13349480	52361
T30	Split Rock Ck (upper)	2000	10	Y	342343	2086014	3449626	22087	562	10886	11448	3176	1298	13794470	71270
T30	Split Rock Ck (upper)	2001	3	N	2684270	6869913	2389045	24264	2546	16538	19132	4814	1973	95185420	50467
T30	Split Rock Ck (upper)	2001	4	Y	9262425	23237210	19224440	220718	26609	158638	185778	46164	18024	327809100	409250
T30	Split Rock Ck (upper)	2001	5	Y	6296430	16231670	5499631	61532	7225	43767	51135	12737	5045	223434100	116877
T30	Split Rock Ck (upper)	2001	6	Y	2883049	8081149	3310256	33125	3408	22418	25891	6526	2462	103195100	69865
T30	Split Rock Ck (upper)	2001	7	Y	342343	2086014	1372102	8785	224	4330	4553	1263	277	13794470	28348
T30	Split Rock Ck (upper)	2001	8	Y	342343	2086014	489724	3136	80	1545	1625	451	30	13794470	10118
T30	Split Rock Ck (upper)	2001	9	Y	331300	2018723	459664	2943	75	1451	1525	423	28	13349480	9497
T30	Split Rock Ck (upper)	2001	10	N	331300	2018723	455282	2915	74	1437	1511	419	28	13349480	9406
T31	Split Rock Ck (lower)	2000	7	N	90651	510910	420685	8065	106	1814	1935	334	33	4171707	8799
T31	Split Rock Ck (lower)	2000	8	Y	293847	1656116	1363653	19231	343	5880	6271	1082	196	9947913	28523
T31	Split Rock Ck (lower)	2000	9	Y	142733	804440	662379	18611	167	2856	3046	526	39	9627013	13855
T31	Split Rock Ck (lower)	2000	10	Y	161130	908127	747756	19231	188	3224	3439	593	47	9947913	15641
T31	Split Rock Ck (lower)	2001	3	N	2628185	6362926	3766430	49108	3783	27476	31742	8330	1947	607602500	91769
T31	Split Rock Ck (lower)	2001	4	Y	22988330	37218350	14549350	310259	34642	185522	224525	69922	13138	4235890000	446255
T31	Split Rock Ck (lower)	2001	5	Y	23447110	37382270	14262170	342127	35382	187504	227338	71225	12644	4689024000	443970
T31	Split Rock Ck (lower)	2001	6	Y	20673150	32959670	12574850	331091	31196	165321	200442	62798	10762	4537765000	391445
T31	Split Rock Ck (lower)	2001	7	Y	18847690	30394820	11809210	331711	28412	151750	183738	57308	9379	4538086000	363560
T31	Split Rock Ck (lower)	2001	8	Y	16574780	27082070	10736960	321295	24956	134498	162597	50454	8014	4387149000	326535
T31	Split Rock Ck (lower)	2001	9	Y	4519626	11713700	7246802	81107	6440	49543	56809	14448	3510	915254500	172728
T31	Split Rock Ck (lower)	2001	10	N	16247570	27065420	11041800	258179	24420	133383	160879	49540	8812	3481200000	330102
T32	Beaver Ck (upper)	2000	7	N	120028	432392	364106	3423	52	838	872	131	78	8172281	7233
T32	Beaver Ck (upper)	2000	8	Y	32813	113650	99540	936	14	200	209	31	26	2234151	1977
T32	Beaver Ck (upper)	2000	9	Y	177167	575217	537439	5052	76	868	905	131	194	12062710	10676
T32	Beaver Ck (upper)	2000	10	Y	216930	728223	658062	6186	93	1191	1240	182	201	14770050	13072
T32	Beaver Ck (upper)	2001	3	N	2363688	2191542	718621	15699	2539	8791	12806	3518	2510	8035540	27373
T32	Beaver Ck (upper)	2001	4	Y	8721948	9863488	2651695	57928	9367	44982	58527	17026	6846	29650930	101004
T32	Beaver Ck (upper)	2001	5	Y	4422280	4044219	1594057	31371	4691	15170	22401	5908	6188	20948560	55663
T32	Beaver Ck (upper)	2001	6	Y	4407939	5304421	1992160	34501	4581	21673	28307	7718	4407	30437890	62674
T32	Beaver Ck (upper)	2001	7	Y	2670157	3600460	1808440	25721	2633	12530	16477	4035	3083	32697160	48695
T32	Beaver Ck (upper)	2001	8	Y	571250	1876620	1419402	13777	320	4615	4970	824	422	31464880	28831
T32	Beaver Ck (upper)	2001	9	Y	339383	1253905	1029524	9677	146	2587	2690	410	194	23107450	20450
T32	Beaver Ck (upper)	2001	10	N	321641	1174223	975704	9172	139	2348	2443	370	194	21899450	19381
T33	Beaver Ck (lower)	2000	7	N	63337	238896	361914	1801	40	545	553	114	35	1207613	3188
T33	Beaver Ck (lower)	2000	8	N	13180	49714	120638	375	8	113	106	24	7	251300	663
T33	Beaver Ck (lower)	2000	9	Y	42927	161914	904785	1221	27	369	298	78	24	818471	2160
T33	Beaver Ck (lower)	2000	10	Y	69004	260270	934945	1963	44	593	517	125	38	1315660	3473
T33	Beaver Ck (lower)	2001	3	N	2695096	5152710	7731989	42337	5598	29317	22643	9974	2415	104492500	73004
T33	Beaver Ck (lower)	2001	4	Y	14561240	28234450	18396250	231445	29936	157910	223514	53485	12973	560373300	399366
T33	Beaver Ck (lower)	2001	5	Y	3802800	8520990	10353430	68298	6927	39834	36011	12799	3173	134191800	118633
T33	Beaver Ck (lower)	2001	6	Y	6058640	12737390	9650518	103074	11687	64491	91196	21246	5212	222676000	178532
T33	Beaver Ck (lower)	2001	7	Y	2739649	6676840	4971437	52887	4573	28039	31656	8673	2185	90975260	92190
T33	Beaver Ck (lower)	2001	8	Y	462459	1744321	934945	13153	293	3977	4993	835	253	8817491	23274
T33	Beaver Ck (lower)	2001	9	Y	211953	799450	904785	6028	134	1823	1958	383	116	4041200	10667
T33	Beaver Ck (lower)	2001	10	N	184935	697545	904785	5260	117	1590	1655	334	101	3526073	9307

Appendix W.
MUSLE Sediment Delivery Model Procedures

MUSLE Sediment Delivery Model Procedures

Developed by Calvin Wolter
ArcView Extension Automation Documentation

Define and prepare inputs

1) Watershed Boundary
   a) Convert to grid (if necessary)
   b) Set Analysis Extent to grid extent

2) Soils Grid
   a) Clip to analysis extent
   b) Define Midslope, K-Factor, and LS-Factor

3) Land Cover Grid
   a) Clip to analysis extent
   b) Define C-Factor, P-Factor, and Mannings Roughness Coefficient

4) Elevation Grid
   a) Clip to analysis extent

5) Rainfall Grid
   a) Clip to analysis extent
   b) Define R-Factor

Initial Calculations

1) Fill sinks in Elevation grid
   Subroutine: "CMMFillDEM"

2) Compute Flow Direction from Filled Elevation grid
   Subroutine: "CMMFlowDir"

3) Compute Flow Length from Flow Direction grid
   Subroutine: "CMMFlowLen"

4) Compute Flow Accumulation from Flow Direction grid
   Subroutine: "CMMFlowAcc"

5) Generate average K, LS, C, P, Mannings, and Slope value grids
   Equation: Avg Value Grid = A.GetGrid.FlowAccumulation(B.GetGrid.Lookup(BFld.GetName))/AccGrd
      Where: A = Flow Direction grid, B = grid containing K, LS, C, etc., Bfld = field containing values for K, LS, C, etc., and AccGrd = Flow Accumulation grid

6) Generate Curve Number grid
   Subroutines "CMMCurvNo", and "CMMCurvDeriv"
   Inputs: Hydrologic Group Code and Land Cover Code

7) Compute Drainage Area grids (acres and miles^2)
   Equations: DAac = FlowAcc * 900/4046.8564
      DAsm = DAac/640

8) Identify cells with Flow Length < or > 300 feet

9) Query user for rainfall event (Assume a 24 hour event to 1/100th of an inch)

Primary Calculations

1) Calculate runoff

   S = (1000/Curve No. grid) – 10

   Q = R – $(0.2*S)^2$/R+(0.8*S)

   Where: R = user defined rainfall event

2) Calculate Sheet Flow time of travel

   TtSheet = (A *B*$3.2808^{0.8}$)*0.007/$C^{0.5}$*$D^{0.4}$

   Where: A = Avg. Mannings grid

   B = Flow Length grid

   C = Rainfall Factor grid

   D = Avg. Slope grid

3) Calculate Shallow Concentrated Flow time of travel

   TtShallow = A/3600*(16.1345*$(B)^{0.5}$

   Where: A = Flow Length > 300 grid

   B = Avg. Slope

4) Create Drainage Network

   X = Input Landform Region for drainage size threshold

   Network = Flow Accumulation grid > X

5) Buffer the Drainage Network

   DrainBuff = Drain.Expand(1,{1})

6) Create Sub Watersheds

   Subroutine: “CMMSubShed”

7) Calculate average longest time of travel for shallow concentrated flow for each sub

   TcShallow = (TtShallow>0).Con((TtShallow + Avg. TtSheet), 0)

8) Calculate the total Time of Concentration for entire watershed

   TcTotal = TcShallow + TtSheet

9) Calculate Peak Discharge (Qp)

   Ia = S*0.2

   IaR = Ia/R *S and R defined in #1 above

   Remove values < 0.1 and > 0.5

   IaR_2 = (IaR<0.1).Con(0.1, IaR)

   IaR_3 = (IaR_2>0.5).Con(0.5, IaR_2)

   C_0 = ((-2.2349*$(IaR_3)^2$)+(0.4759*IaR_3)+2.5273

   C_1 = ((1.5555*$(IaR_3)^2$)-(0.7081*IaR_3)-0.5584

   C_2 = ((0.6041*$(IaR_3)^2$)+(0.0437*IaR_3)-0.1761

   Qu = (C_0+(C_1*TcTotal.Log10))+(C_2*$(TcTotal.Log10)^2$).Exp10

   Qp = Qu*Dasm*Q

10) Calculate average runoff (inches and acre-feet)

   AvgRunInch = (Flow Direction grid.FlowAccumulation*Q)/Flow Accumulation grid

   AvgRunAcFt = AvgRunInch * (DAac/12)

11) Create raw Sediment Delivery grid (Y)

$Y = 95*((AvgRunAcFt*Qp)^{0.56})*AvgK*AvgLS*AvgC*AvgP$

12) Create the Sediment Delivery Display grid

Subroutine: "CMMDispGrid"

13) Calculate total sediment delivery

Semi = (DrainBuff = 1).Con(Y,0)
Final = (Semi*100).Int

Add new field (TLoss) to Final grid data table

FinalTable.Add(TLoss)

Divide Value field by 100 and multiply the quotient by the Count field to populate TLoss

Summarize all values in Tloss = Total sediment delivered to surface waters in tons

<u>Methodology for Calculating the Modified Universal Soil Loss Equation in ArcView</u>

Calvin Wolter, Iowa DNR/GSB, September 14, 2000

The Modified Universal Soil Loss Equation (MUSLE) is as follows:

Y = 95 * (Q * qp)**0.56 * Kf * LSf * Cf * Pf

where Y is the sediment yield from the watershed in tons per year, Q is the runoff in acre-ft, qp is the peak flow rate for the watershed in cfs, Kf is the soil erodibility factor, LSf is the length/slope factor, Cf is the cropping factor, and Pf is the conservation practice factor.

Kf is derived from the soil data and is obtained from the soil grid. LSf is also derived from the soil data and is calculated from the mean slope of each mapping unit. Cf is derived from the landuse and is obtained from the landuse grid. Pf has to be developed from known areas affected by terraces or ponds and then digitized and gridded.

Q is derived using the SCS runoff curve number equation:

Q = (R – 0.2 * S)**2 / (R + 0.8 * S)

where R is the event rainfall in inches and S is a retention parameter and is calculated from the curve number (CN):
S = (1000 / CN) – 10

Consequently, Q can be calculated using the following equation:

Q = ((R – 0.2 * ((1000 / CN) – 10))**2) / (R + 0.8 * ((1000 / CN) – 10))

The curve number is derived from the landcover and the hydrologic group code in the soil data. In the landcover grid, the values for the landcover are as follows: 1 = artificial; 2 = barren; 3 = grass; 4 = row crop; 5 = water; and 6 = woods. In the soil grid a hydrologic group code number field is created and calculated as follows: hydrologic group code A = 10, code B = 20, code C = 30, and code D = 40. For soils with multiple hydrologic group codes, use the code with a lower numeric value (i.e. B = 20 instead of D = 40). Then add the hydrologic group code number with the landcover value to get unique values for combinations of the landcover and hydrologic group codes. The following table is used to populate the actual curve number field for average soil moisture conditions.

Hydrologic Group Code	A (10)	B (20)	C(30)	D(40)
Landcover				

Artificial (1)	(11) CN = 74	(21) CN = 84	(31) CN = 90	(41) CN = 92
Barren (2)	(12) CN = 72	(22) CN = 82	(32) CN = 87	(42) CN = 89
Grass (3)	(13) CN = 39	(23) CN = 61	(33) CN = 74	(43) CN = 80
Row Crop (4)	(14) CN = 68	(24) CN = 78	(34) CN = 85	(44) CN = 88
Water (5)	(15) CN = 0	(25) CN = 0	(35) CN = 0	(45) CN = 0
Woods (6)	(16) CN = 25	(26) CN = 55	(36) CN = 70	(46) CN = 77

The CN should be adjusted for antecedent soil moisture conditions (AMC). The average condition (RCN(II)) is defined as having 1.4 to 2.1 inches of rain in the previous five days during the growing season or 0.5 to 1.1 inches during the dormant season. Dry AMC (RCN(I)) are defined as having less than 1.4 inches of rain in the previous five days during the growing season or less than 0.5 inches during the dormant season. Wet AMC (RCN(III)) are defined as having greater than 2.1 inches of rain during the previous five days during the growing season or greater than 1.1 inches during the dormant season. The following equations are then used to adjust the CN for the appropriate conditions.

RCN(I) = 4.2 * RCN(II) / (10 - 0.058 * RCN(II))
RCN(III) = 23 * RCN(II) / (10 + 0.18 * RCN(II))

A grid of the county annual R factors has been created and a value for the 2-year 24-hour rainfall event was calculated from this and is used to calculate Q along with the curve number.

To calculate the peak discharge the graphical peak discharge method as presented in TR-55 (Urban Hydrology for Small Watersheds) by the SCS is used. The equation for peak discharge is:

qp = qu * Am * Q

where qp is the peak discharge in cfs, qu is the unit peak discharge in cfs/sq mi/in, Am is the drainage area in square miles and Q is the runoff in inches.

To calculate the peak unit discharge, the value for initial abstraction (Ia) divided by P (rainfall in inches) needs to be calculated. Ia is calculated from the equation Ia = 0.2 * S where S is ((1000/CN) – 10). So this can be calculated in the curve number grid. P is obtained from the annual R factor grid and the value of Ia/P can then be calculated. If the value of Ia/P is less than 0.1, set it equal to 0.1. If the value of Ia/P is greater than 0.5, set it equal to 0.5. This is so that it will work properly with the equations for calculating qu. Use the equation ([Ia/P] < 0.1.asgrid).con(0.1.asgrid, [Ia/P]).

The time of concentration for each point in the watershed then needs to be calculated. This is also done by following the method in the SCS TR-55, calculating a travel time for sheet flow and a travel time for shallow concentrated flow and adding the two together as needed. To calculate travel times, a flow length grid should be created from the flow direction grid of a filled DEM and should not be calculated to an outlet but from the ridge line. The Manning's roughness coefficient needs to be created in the landcover grid as follows:

Landcover	Manning's Roughness Coefficient
Artificial	0.01
Barren	0.05
Grass	0.2
Row Crop	0.11
Water	0
Woods	0.5

An average Manning's roughness coefficient can then be calculated by running the FlowLength command on the FlowDirection grid using the Manning's roughness coefficient in the Landcover grid as a modifier and then dividing by the normal FlowLength grid.

FlowDirGrid.FlowLength([LanduseGrid.ManningNum], true)/[FlowLengthGrid]

An average slope grid can be created the same way by using the soils mean slope value as the modifier in the FlowLength calculation and dividing by the normal FlowLength grid. The time of travel for the sheet flow, which is the first 300 feet of flow, is calculated using the following equation:

Ttsheet = ((avg Manning N * FlowLength * 3.2808.asGrid) ** 0.8) * 0.007.asGrid / ((P)**0.5 * (avg slope)**0.4)

where the travel time is in hours, slope is in ft/ft and P is the 2-year 24-hr rainfall in inches.

To create a grid with the time of travel for sheet flow for only the first 300 feet, create a grid from the FlowLength grid so that it has a value of 1 in the first 300 feet and a value of 0 for the rest of the grid. The equation FlowLength <= 91.44111.asGrid will create such a grid. Use this grid as a conditional grid to populate a new grid with the Tts values for only the first 300 feet using the following equation

([FlowLength<=300] = 1).con(Ttsheet, 0.asGrid)

To calculate the time of travel for shallow concentrated flow the following equations are used:

V = 16.1345 * (s)**0.5 and Ttshallow = L / (3600 * V)

where V is in ft/sec, L is in feet and s is the slope in ft/ft.

The equations can be combined to Ttshallow = L / (3600 * (16.1345 * (s)**0.5))

To get the correct value of L from the flow length grid, only the area with a flow length greater than 300 ft should be used and then 300 feet must be subtracted from it. This is done with the following equation:

([FlowLength] <= 91.44111).con(0.asGrid,([FlowLength] * 3.2808.asGrid) – 300.asGrid)

Ttshallow can then be calculated using that grid and the slope grid from the soil data. However, to get the total time of concentration in the area with a flow length greater than 300 feet, the time of travel for the sheet flow has to be added to the time of travel for the shallow flow. Unfortunately, a way of doing this automatically in ArcView has not been found. So, the average longest time of travel in the sheet flow region is added to all the time of travel in the shallow flow region. To find the average longest time of travel, tabulate an integer grid of flow length vs. and integer grid of sheet time of travel. Use sheet time of travel in the row and flow length in the column. Then select the average value at 90 meters and add it to the shallow concentrated flow time of travel using the following equation:

Tcshallow = ([Ttshallow > 0.asGrid).con(([Ttshallow] + avg Ttsheet), 0.asGrid)

Then the Tcshallow and Ttsheet grids can be added together to create a Tc grid for the whole watershed.

The Unit Peak Discharge is then calculated from the equation:

Log(qu) = C0 + C1 * log(Tc) + C2 *(log(Tc)**2)

The values of C0, C1 and C2 are calculated from the initial abstraction / P grid and the following equations:

C0 = -2.2349 * (Ia/P)**2 + 0.4759 * (Ia/P) + 2.5273
C1 = 1.5555 * (Ia/P)**2 – 0.7081 * (Ia/P) – 0.5584
C2 = 0.6041 * (Ia/P)**2 + 0.0437 * (Ia/P) – 0.1761

The grid of Unit Peak Discharge can then be calculated using the equation

qu = (C0 + C1 * log(Tc) + C2 * (log(Tc)**2)).exp10

The Peak Discharge is then calculated from qu, Am and Q. Finally, the sediment yield can be calculated from the MUSLE. However, the value for Q has to be converted from inches to acre-feet by the following equation:

Q(acre-ft) = Q(inches) * Drainage Area(acres) / 12

The average values for the Kf, LSf, Cf, and Pf (if available) need to be calculated using the procedure previously described for the average Manning's coefficient

The equation for the sediment yield is then

Y = 95.asGrid * (Q * qp) ** 0.56 * avg Kf * avg LSf * avg Cf * avg Pf

This gives a total sediment yield, in tons, for each cell as it drains into the stream channel. To calculate the total yield for the watershed, the total from only the cells adjacent to the stream channels needs to be calculated. This can be accomplished by creating a buffer grid around the drainage grid using the following equation

DrainBuf = ([Drainage].expand(1,{1})

Where the buffer area has a value of 1 and the rest of the watershed a value of 0.
This buffer grid can than be used to select only the cells from the sediment yield grid that are adjacent to the stream channel using the following equation.

([DrainBuf] = 1.AsGrid).con([MUSLE avg values], 0.AsGrid)

The total sediment delivered to the stream is then the sum of the values for the last grid and is in tons.

Appendix X.
SDM Contract

Memorandum of Understanding (MOU)

Sediment Delivery Modeling for the Central Big Sioux River Watershed Assessment Project

Parties to the Agreement

The parties to this agreement are the East Dakota Water Development District, and Department of Wildlife and Fisheries Sciences, South Dakota State University.

Purpose of the Agreement

The purpose of this MOU is to define the products, budgets and timelines for sediment delivery modeling to be performed by the Department of Wildlife and Fisheries Sciences at South Dakota State University for East Dakota Water Development District.

Understanding of Products to be Delivered

East Dakota Water Development District intends that the primary purpose for obtaining the specified products through the sediment delivery modeling are to 1) determine how land uses are affecting sediment delivery to tributaries and to the Big Sioux River and 2) identify critical areas in the watershed that have a high potential to reduce sediment delivery if treated with proper landuse practices.

The following products are specified and understood by all the parties to this agreement:

1. A sediment yield will be determined for 33 tributary monitoring sites using the latest version of a Sediment Delivery Model developed by Calvin Wolter of the Iowa Department of Natural Resources, Bureau of Geology. Critical areas in the central Big Sioux River watershed, including Minnesota portions, that are delivering high sediment loads to tributaries will be identified with the sediment delivery model.

2. Predictions in sediment yield reductions will be determined under a series of land use change scenarios to determine which land areas and management practices would be most useful for meeting sediment reduction needs.

3. Percentages of landuse types above each of the 33 monitoring stations will be determined.

4. Stream buffer condition will be quantified (longitudinal distance) by categorizing landuse type, buffer width, and stream order above each of the 33 monitoring stations.

Procedural Guidelines

The GIS staff in the Department of Wildlife and Fisheries Sciences will use the Sediment Delivery Model developed by Calvin Wolter with Iowa Department of Natural Resources, Bureau of Geology. When product 1 is completed, the Project Coordinator for the Watershed Assessment and GIS staff will review findings. A series of land use change scenarios will be selected that have the highest potential for sediment reductions. These landuse change scenarios will be modelled and sediment reduction predictions determined. For Product 4, the Project Coordinator for the Watershed Assessment and GIS staff will determine which combination of landuse type and buffer width are appropriate and practical for categorizing stream buffer condition.

Responsibilities of the Parties

The GIS office will be responsible for delivering the 4 products as given above. EDWDD will be responsible for providing personnel aid in obtaining key soil layers and for consulting with local conservation district personnel regarding landuse checks and history as needed.

Timelines

This sediment delivery modeling project will occur beginning March 1, 2001. The 4 products as listed above will be completed by February 28, 2002. Additional modeling procedures may occur from March 1, 2002 to May 31, 2002 if further landuse change scenarios are deemed by cooperators as necessary to meet the landuse modeling goals in the watershed assessment proposal. This decision will be based on the ability of previous models to show that potential reductions in sediment delivery will allow water quality to meet WQ standards.

Budget for Sediment Load Modeling

Budget needed to produce products 1 to 3 for the period March 1, 2001 to February 28, 2002.

Item	Cost
Personnel	$23,000
Benefits	$5,600
Computer Hardware	$2,000
Computer Software	$350
Landsat 7 Imagery	$2,100
Misc. Supplies and Materials	$2,000
Total Expenses	$35,050
Indirect Costs @ 10%*	$3,505
Project Total Costs	$38,555

*EDWDD standard overhead rate

Budget needed to produce product 4 for the period March 1, 2001 to February 28, 2002.

Item	Cost
Personnel	$11,500
Benefits	$2,800
Misc. Supplies and Materials	$500
Total Expenses	$14,800
Indirect Costs @ 10%*	$1,480
Project Total Costs	$16,280

*EDWDD standard overhead rate

Any capital assets purchased with funds provided by this Memorandum of Understanding will revert back to East Dakota Water Development upon termination of stated activities.

By their signature affixed below, each party acknowledges their acceptance and approval of this agreement.

____

Dr. John J. Ruffolo Date
Associate Dean, Research
South Dakota State University

____

Manager/Treasurer Date
East Dakota Water Development District

Appendix Y.
SDM Yields for 2, 5, 10, and 20 Year Rainfall Events

Y-1

SDM Yields for 2, 5, 10, and 20 Year Rainfall Events

LMU	SubWatershed	Tributary Ref Point	River Ref Point	Area Acres	2yr SDY	2yr Tons/Acre	5yr SDM Yield	5yr Tons/Acre	10yr SDM Yield	10yr Tons/Acre	20yr SDM Yield	20yr Tons/Acre
E	na	na	R1	25708	11110	0.432	20585	0.801	26409	1.027	31425	1.222
A	na	na	R1	52023	16356	0.314	30860	0.593	39965	0.768	47853	0.920
B	na	na	R1	2677	554	0.207	1365	0.510	2052	0.767	2790	1.042
R1	R1	na	R1	51005	12707	0.249	32546	0.638	50125	0.983	69386	1.360
G	G	na	R2	2910	793	0.272	1948	0.669	2940	1.010	4008	1.377
1	T2	T1	R2	31765	10871	0.342	22503	0.708	31599	0.995	41273	1.299
2	T2	T2	R2	52251	17119	0.328	42392	0.811	63895	1.223	87064	1.666
F	T2	na	R2	1110	6	0.005	13	0.012	19	0.017	26	0.023
D	T5	na	R2	3665	786	0.214	1942	0.530	2933	0.800	4003	1.092
MM	T5	na	R2	238	0	0.000	0	0.000	0	0.000	0	0.000
3	T5	T3	R2	18657	5191	0.278	13670	0.733	21264	1.140	29595	1.586
4	T5	T4	R2	17499	4798	0.274	11927	0.682	18077	1.033	24736	1.414
5	T5	T5	R2	6921	923	0.133	2345	0.339	3579	0.517	4918	0.711
R2	R2	na	R2	4213	107	0.025	269	0.064	408	0.097	558	0.132
I	I	na	R3	49512	25261	0.510	59975	1.211	89211	1.802	120626	2.436
J	T10	na	R3	96	11	0.114	22	0.228	31	0.322	41	0.425
C	C	na	R3	9342	1729	0.185	4505	0.482	6959	0.745	9635	1.031
10	T10	T10	R3	113324	53346	0.471	115152	1.016	162543	1.434	210837	1.860
O	T10	na	R3	6289	2048	0.326	4970	0.790	7465	1.187	10151	1.614
R3	R3	na	R3	26654	4654	0.175	11810	0.443	18124	0.680	25015	0.939
6	T9	T6	R4	36737	8435	0.230	23434	0.638	37552	1.022	53401	1.454
K	T9	na	R4	407	0	0.000	0	0.000	0	0.000	0	0.000
7	T9	T7	R4	1540	299	0.194	762	0.495	1155	0.750	1581	1.027
8	T9	T8	R4	25688	7445	0.290	18982	0.739	29012	1.129	39905	1.553
9	T9	T9	R4	39711	13357	0.336	33204	0.836	50196	1.264	68543	1.726
L	T9	na	R4	2335	279	0.119	655	0.281	972	0.416	1313	0.562
N	N	na	R4	1369	207	0.151	492	0.359	728	0.532	979	0.715
R4	R4	na	R4	2504	787	0.314	1936	0.773	2921	1.166	3983	1.590
Q	Q	na	R5	2486	692	0.278	1525	0.613	2169	0.872	2825	1.136
M	M	na	R5	19125	7589	0.397	18813	0.984	28446	1.487	38849	2.031
P	P	na	R5	30688	11395	0.371	28732	0.936	43708	1.424	59931	1.953
11	T11	T11	R5	30887	10636	0.344	27102	0.877	41256	1.336	56553	1.831

R	T11	na	R5	856	65	0.076	177	0.207	278	0.325	390	0.456
S	S	na	R5	1783	457	0.256	1169	0.656	1787	1.002	2456	1.378
R5	R5	na	R5	1087	237	0.218	563	0.518	830	0.764	1114	1.025
OO	OO	na	R6	12277	5764	0.470	14592	1.189	22175	1.806	30361	2.473
12	T12	T12	R6	2597	438	0.169	1276	0.491	2064	0.795	2943	1.133
T	T12	na	R6	10742	3843	0.358	9835	0.916	15056	1.402	20740	1.931
R6	R6	na	R6	16071	4203	0.262	10330	0.643	15358	0.956	20595	1.281
13	T13	T13	R7	33419	13845	0.414	32039	0.959	46455	1.390	61269	1.833
U	T13	na	R7	3996	1920	0.480	4539	1.136	6634	1.660	8793	2.200
14	T14	T14	R7	72251	37956	0.525	80202	1.110	113011	1.564	146331	2.025
X	T14	na	R7	465	34	0.073	77	0.166	111	0.239	156	0.336
R7	R7	na	R7	21078	5884	0.279	14111	0.669	20728	0.983	27580	1.308
W	W	na	R8	17381	9037	0.520	20498	1.179	29316	1.687	38289	2.203
R8	R8	na	R8	37555	18939	0.504	42646	1.136	61256	1.631	80345	2.139
AA	AA	na	R9	21821	18011	0.825	36401	1.668	50153	2.298	63562	2.913
R9	R9	na	R9	517	92	0.178	175	0.339	235	0.455	292	0.565
V	T23	na	R10	60334	27665	0.459	46475	0.770	57606	0.955	67246	1.115
17	T23	T17	R10	9011	2849	0.316	5994	0.665	8410	0.933	10867	1.206
18	T23	T18	R10	17577	8269	0.470	18093	1.029	25673	1.461	33405	1.900
15	T23	T15	R10	50453	31140	0.617	52217	1.035	64747	1.283	75900	1.504
16	T23	T16	R10	5889	2686	0.456	5655	0.960	7937	1.348	10252	1.741
19	T23	T19	R10	40549	49409	1.219	78891	1.946	95887	2.365	110453	2.724
Y	T23	na	R10	27992	26893	0.961	52347	1.870	70545	2.520	87945	3.142
20	T23	T20	R10	43236	35482	0.821	69046	1.597	93060	2.152	116015	2.683
21	T23	T21	R10	40934	31469	0.769	63552	1.553	87028	2.126	109674	2.679
22	T23	T22	R10	30682	35729	1.164	69564	2.267	93814	3.058	116993	3.813
BB	T23	na	R10	12624	11961	0.948	22548	1.786	29999	2.376	37074	2.937
23	T23	T23	R10	32531	19061	0.586	38087	1.171	51838	1.593	65051	2.000
II	T23	na	R10	759	17	0.022	38	0.050	54	0.071	71	0.094
R10	R10	na	R10	13897	3615	0.260	7165	0.516	9739	0.701	12221	0.879
JJ	JJ	na	R11	5125	1374	0.268	2939	0.573	4105	0.801	5240	1.022
24	T24	T24	R11	18029	11959	0.663	23643	1.311	32175	1.785	40413	2.242
CC	T24	na	R11	4208	3017	0.717	5683	1.350	7544	1.793	9306	2.211
R11	R11	na	R11	11187	1156	0.103	2634	0.235	3802	0.340	4968	0.444
25	T25	T25	R12	14624	12220	0.836	24913	1.704	34352	2.349	43493	2.974
EE	T25	na	R12	4780	1580	0.331	3403	0.712	4800	1.004	6167	1.290
FF	FF	na	R12	7553	1394	0.185	3183	0.421	4594	0.608	5993	0.793

R12	R12	na	R12	6888	9056	1.315	17194	2.496	22949	3.332	27172	3.945
26	T31	T26	R13	33011	20087	0.608	40672	1.232	55477	1.681	69680	2.111
27	T31	T27	R13	21431	26004	1.213	48589	2.267	64444	3.007	79476	3.709
DD	T31	na	R13	374	130	0.347	291	0.778	418	1.117	542	1.449
28	T31	T28	R13	3698	1911	0.517	4366	1.181	6249	1.690	8164	2.208
29	T31	T29	R13	37812	22695	0.600	46699	1.235	64051	1.694	80726	2.135
Z	T31	na	R13	4483	2514	0.561	5460	1.218	7670	1.711	9820	2.190
30	T31	T30	R13	1137	1266	1.113	2237	1.967	2906	2.555	3535	3.108
31	T31	T31	R13	27031	28103	1.040	54058	2.000	72708	2.690	92378	3.417
GG	T31	na	R13	12364	7209	0.583	14493	1.172	19783	1.600	24898	2.014
33	T33	T33	R13	27184	24081	0.886	46771	1.721	63115	2.322	78773	2.898
HH	T33	na	R13	203	6	0.030	30	0.148	40	0.197	33	0.162
R13	R13	na	R13	11362	4567	0.402	9156	0.806	12475	1.098	14160	1.246
KK	na	na	R14	3081	889	0.289	1892	0.614	2650	0.860	3392	1.101
LL	na	na	R14	6904	4354	0.631	8591	1.244	11672	1.691	14637	2.120

Appendix Z.
SDM Yields Based on Land Use Scenarios for 2 Year and 20 Year Rainfall

Sediment Yield in Tons (20 Year Rainfall Event)

LMU	Inch Event	Original	30m Buffer	% Reduce	Contour Strips*	% Reduce	Contour/ Stream Buffer	% Reduce	No Till	% Reduce	Stream Buffer/ No Till	% Reduce	Pristine	% Reduce
Y	4.37	87945	84322	4	66892	24	64324	27	25705	71	24675	72	1905	98
R8	4.31	80345	76785	4	69398	14	66408	17	23524	71	22472	72	2408	97
AA	4.37	63562	61587	3	41508	35	40223	37	17768	72	17216	73	1398	98
T19	3.68	110453	107571	3	82860	25	80906	27	32771	70	31910	71	2041	98
T20	4.37	116015	110356	5	98364	15	94084	19	33600	71	31986	72	2538	98
T21	4.37	109674	102449	7	90454	18	88545	19	31392	71	30746	72	2383	98
T22	4.37	116993	112241	4	74295	36	71214	39	42278	64	40670	65	2986	97
BB	4.37	37074	34367	7	23534	37	21843	41	14980	60	14035	62	1173	97
R10	4.37	12221	12202	0	10454	14	10419	15	4003	67	3992	67	410	97
T27	4.37	79476	75642	5	50889	36	48367	39	24638	69	23477	70	1619	98
T24	4.37	40413	38153	6	31116	23	29228	28	12114	70	11436	72	870	98
T25	4.37	43493	40999	6	32726	25	30738	29	12556	71	11831	73	874	98
EE	4.37	6127	5741	6	4915	20	4616	25	3242	47	2978	51	322	95
T31	4.37	92378	87961	5	61081	34	58268	37	25788	72	24417	74	1819	98
T33	4.37	78773	75836	4	58034	26	55750	29	23916	70	23087	71	1627	98
GG	4.37	24898	24586	1	18955	24	18748	25	7699	69	7606	69	615	98
R12	4.37	27172	26545	2	16356	40	15320	44	8630	68	8055	70	639	98
T1	3.83	41273	37953	8	x		x		12058	71	11103	73	953	98
T2	4.66	87064	82800	5	x		x		25261	71	24047	72	1779	98
T3	4.66	29595	27771	6	x		x		8680	71	8147	72	720	98
T4	4.66	24736	23030	7	x		x		7185	71	6634	73	509	98
T5	4.66	4918	4811	2	x		x		1497	70	1472	70	145	97
T6	4.66	53401	51443	4	x		x		16593	69	16028	70	2565	95
T7	4.66	1581	1568	1	x		x		466	71	466	71	46	97
T8	4.66	39905	37645	6	x		x		11699	71	11047	72	944	98
T9	4.66	68543	65162	5	x		x		19898	71	18931	72	1410	98
T10	4.31	210837	see below		x		x		see below		see below		see below	
T11	4.66	56553	53888	5	x		x		16497	71	15706	72	1229	98
T12	4.66	2943	2765	6	x		x		883	70	831	72	96	97
T13	4.31	61269	58190	5	x		x		17815	71	16925	72	1280	98
T14	4.31	146331	145060	1	x		x		43568	70	42307	71	3317	98

T15	3.68	75900	73929	3	x	x	21938	71	21426	72	1609	98
T16	4.31	10252	9956	3	x	x	2991	71	2901	72	232	98
T17	4.31	10867	10689	2	x	x	3175	71	3120	71	250	98
T18	4.31	33405	32797	2	x	x	9903	70	9723	71	958	97
T23	4.37	65051	62368	4	x	x	18952	71	18256	72	1464	98
T26	4.37	69680	66134	5	x	x	19904	71	18902	73	1162	98
T28	4.31	8164	7499	8	x	x	2352	71	2163	74	144	98
T29	4.37	80726	74515	8	x	x	23087	71	21315	74	1327	98
T30	4.37	3535	3165	10	x	x	1019	71	914	74	62	98
R1	4.66	69386	67902	2	x	x	20627	70	20195	71	2094	97
R2	4.66	558	550	1	x	x	175	69	172	69	30	95
R3	4.66	25015	23824	5	x	x	7539	70	7192	71	837	97
R4	4.66	3983	3704	7	x	x	1177	70	1096	72	108	97
R5	4.66	1114	1114	0	x	x	389	65	389	65	117	90
R6	4.31	20595	19960	3	x	x	6199	70	6017	71	719	97
R7	4.31	27580	26211	5	x	x	8145	70	7754	72	767	97
R9	4.37	292	292	0	x	x	92	69	92	69	15	95
R11	4.37	4968	4892	2	x	x	1678	66	1668	66	313	94
R13	4.37	14165	13760	3	x	x	8011	43	7798	45	981	93
B	4.66	2790	2528	9	x	x	805	71	730	74	50	98
C	4.66	9635	9283	4	x	x	2791	71	2692	72	192	98
D	4.66	4003	3603	10	x	x	1157	71	1043	74	76	98
E	3.63	31425	29382	7	x	x	9261	71	8889	72	1137	96
F	4.66	26	23	10	x	x	8	70	7	73	1	97
G	4.66	4008	3768	6	x	x	1160	71	1089	73	77	98
I	4.66	120626	118305	2	x	x	35694	70	35010	71	3409	97
J	4.66	41	41	0	x	x	15	63	15	63	5	87
K	no drainage output				x	x						
L	4.66	1313	1313	0	x	x	391	70	391	70	39	97
M	4.66	38849	38205	2	x	x	11370	71	11185	71	915	98
N	4.66	979	970	1	x	x	288	71	285	71	26	97
O	4.66	10151	10009	1	x	x	2999	70	2954	71	283	97
P	4.66	59931	58436	2	x	x	18112	70	17662	71	2213	96
Q	4.31	2825	2735	3	x	x	846	70	820	71	96	97
R	4.66	390	375	4	x	x	127	67	123	69	27	93
S	4.66	2456	2034	17	x	x	743	70	620	75	90	96
T	4.66	20740	19784	5	x	x	6138	70	5866	72	592	97

U	4.31	8793	7482	15	x	x	2596	70	2201	75	236	97
V	3.68	67246	66125	2	x	x	19653	71	19388	71	1613	98
W	4.31	38289	35521	7	x	x	10992	71	10203	73	617	98
X	4.31	156	156	0	x	x	46	71	43	72	4	98
Z	4.37	9820	9124	7	x	x	2824	71	2623	73	164	98
CC	4.37	9306	8714	6	x	x	2674	71	2508	73	156	98
DD	4.37	542	542	0	x	x	157	71	157	71	11	98
FF	4.37	5993	5788	3	x	x	2895	52	2826	53	446	93
HH	4.37	33	33	0	x	x	10	71	10	71	1	97
II	4.37	71	71	0	x	x	22	69	22	69	3	96
JJ	4.37	5240	5023	4	x	x	1528	71	1472	72	117	98
MM	no drainage output				x	x						
OO	4.66	30361	29255	4	x	x	8789	71	8472	72	593	98
camp1	4.31	87373	86871	1	x	x	25402	71	25258	71	1841	98
camp2	4.31	123464	121051	2	x	x	36181	71	35477	71	2984	98

Sediment Yield in Tons (2 Year Rainfall Event)

LMU	Inch Event	Original	Stream Buffer	% Decrease	Contour buffers*	% Decrease	Contour/ Stream Buffer	% Decrease	No Till	% Decrease	Stream Buffer/ No Till	% Decrease	Pristine	% Decrease
Y	2.44	26893	25147	6	19941	26	18722	30	7816	71	7316	73	544	98
R8	2.28	18939	17385	8	16141	15	14848	22	5513	71	5059	73	531	97
AA	2.44	18011	16992	6	11871	34	11217	38	5098	72	4815	73	378	98
T19	2.45	49409	47343	4	36796	26	35474	28	14648	70	14081	72	885	98
T20	2.44	35482	32850	7	29945	16	27882	21	10253	71	9461	73	736	98
T21	2.44	31469	29981	5	26319	16	25045	20	9031	71	8675	72	656	98
T22	2.44	35729	33475	6	22546	37	21090	41	13001	64	12215	66	887	98
BB	2.44	11961	10403	13	7502	37	6551	45	4808	60	4260	64	363	97
R10	2.44	3615	3589	1	3036	16	3020	16	1189	67	1184	67	109	97
T27	2.44	26004	23857	8	16380	37	14967	42	8086	69	7416	71	506	98
T24	2.44	11955	10876	9	9078	24	8195	31	3601	70	3274	73	241	98
T25	2.44	12220	10880	11	9163	25	8100	34	3536	71	3148	74	233	98
EE	2.44	1580	1345	15	1242	21	1073	32	843	47	699	56	77	95
T31	2.44	28103	25105	11	18616	34	16823	40	8005	72	7260	74	528	98
T33	2.44	24081	22210	8	17451	28	16011	34	7303	70	6778	72	469	98
GG	2.44	7209	7023	3	5476	24	5356	26	2216	69	2162	70	164	98
R12	2.44	9056	8043	11	5096	44	4533	50	2718	70	2405	73	191	98
T1	2.24	10871	9346	14	x		x		3152	71	2713	75	225	98
T2	2.29	17119	15664	8	x		x		4923	71	4507	74	303	98
T3	2.29	5191	4554	12	x		x		1508	71	1320	75	106	98
T4	2.29	4798	3971	17	x		x		1379	71	1142	76	84	98
T5	2.29	923	865	6	x		x		278	70	261	72	24	97
T6	2.29	8435	7894	6	x		x		2561	70	2401	72	327	96
T7	2.29	299	297	1	x		x		87	71	87	71	8	97
T8	2.29	7445	6588	12	x		x		2161	71	1912	74	153	98
T9	2.29	13357	12074	10	x		x		3846	71	3478	74	244	98
T10	2.28	53346	see below		x		x		see below		see below		1136	98
T11	2.29	10636	9600	10	x		x		3078	71	2775	74	204	98
T12	2.29	438	430	2	x		x		148	66	129	71	14	97
T13	2.28	13845	12605	9	x		x		4006	71	3647	74	269	98
T14	2.28	37956	36152	5	x		x		11020	71	10495	72	791	98
T15	2.45	31140	30074	3	28447	9	27493	12	8996	71	8691	72	632	98
T16	2.28	2686	2532	6	2306	14	2241	17	782	71	735	73	59	98
T17	2.28	2849	2744	4	x		x		829	71	798	72	62	98
T18	2.28	8269	7995	3	7764	6	7495	9	2437	71	2356	72	219	97
T23	2.44	19061	17674	7	17438	9	16467	14	5481	71	5152	73	413	98
T26	2.44	20087	18433	8	19573	3	17875	11	5713	72	5244	74	310	98
T28	2.28	1911	1652	14	1910	0	1646	14	548	71	474	75	31	98
T29	2.44	22695	19781	13	22318	2	19431	14	6461	72	5630	75	345	98

T30	2.44	1266	1071	15	x	x	365	71	308	76	21	98
R1	2.29	12707	12308	3	x	x	3730	71	3614	72	329	97
R2	2.29	107	105	1	x	x	33	69	32	70	5	95
R3	2.29	4654	4230	9	x	x	1381	70	1257	73	132	97
R4	2.29	787	669	15	x	x	231	71	197	75	20	97
R5	2.29	237	237	0	x	x	82	65	82	65	24	90
R6	2.28	4203	3945	6	x	x	1251	70	1177	72	131	97
R7	2.28	5884	5312	10	x	x	1723	71	1559	74	148	97
R9	2.44	92	92	0	x	x	29	69	29	69	4	95
R11	2.44	1156	1090	6	x	x	382	67	363	69	63	95
R13	2.44	4567	4214	8	x	x	2260	51	2165	53	262	94
B	2.29	554	451	19	x	x	158	71	129	77	9	98
C	2.29	1729	1603	7	x	x	496	71	460	73	30	98
D	2.29	786	647	18	x	x	225	71	185	77	12	98
E	2.33	11110	10052	10	x	x	3224	71	3025	73	385	97
F	2.29	6	5	11	x	x	2	71	1	74	0	97
G	2.29	793	729	8	x	x	228	71	209	74	14	98
I	2.29	25261	24356	4	x	x	7445	71	7178	72	680	97
J	2.29	11	11	0	x	x	4	63	4	63	1	87
K	no drainage output				x	x						
L	2.29	276	276	0	x	x	81	71	81	71	7	98
M	2.29	7589	7374	3	x	x	2204	71	2142	72	161	98
N	2.29	207	205	1	x	x	60	71	60	71	5	98
O	2.29	2048	2004	2	x	x	602	71	588	71	53	97
P	2.29	11395	10758	6	x	x	3415	70	3222	72	387	97
Q	2.28	692	664	4	x	x	204	71	196	72	19	97
R	2.29	65	60	8	x	x	20	69	19	71	3	95
S	2.29	457	294	36	x	x	137	70	90	80	16	97
T	2.29	3843	3474	10	x	x	1127	71	1022	73	97	97
U	2.28	1920	1361	29	x	x	566	71	398	79	51	97
V	2.45	27665	26963	3	x	x	8049	71	7872	72	626	98
W	2.28	9037	7779	14	x	x	2583	71	2223	75	135	99
X	2.28	34	32	8	x	x	10	71	10	71	1	98
Z	2.44	2514	2214	12	x	x	720	71	634	75	39	98
CC	2.44	3017	2751	9	x	x	865	71	789	74	48	98
DD	2.44	130	130	0	x	x	38	71	38	71	3	98
FF	2.44	1394	1219	13	x	x	683	51	602	57	94	93
HH	2.44	6	6	0	x	x	2	71	2	71	0	98
II	2.44	17	17	0	x	x	5	70	5	70	1	96
JJ	2.44	1374	1271	7	x	x	395	71	369	73	27	98
MM	no drainage output				x	x						
OO	2.29	5764	5313	8	x	x	1661	71	1531	73	103	98
camp1	2.28	22519	22286	1	x	x	6520	71	6453	71	447	98
camp2	2.28	30827	29786	3	x	x	8983	71	8678	72	689	98

Appendix AA.
Fecal Coliform Bacteria Flow Duration Interval Graph Data

Fecal Coliform Bacteria Flow Duration Interval Graph Data

Site	Grab Data (May-Sep) Years		Discharge Data Years		Remarks
	EDWDD	DENR	EDWDD	USGS	
T01	1999-2000	----	1999-2000	----	
T02	1999-2000	----	1999-2000	----	
T03	1999-2000	----	1999-2000	----	
T04	1999-2000	----	1999-2000	1970-1980	USGS Station # 06479910
T05	1999-2000	----	1999-2000	----	
T06	1999-2000	----	1999-2000	----	
* T07	1999-2000	----	1999-2000	----	
* T08	1999-2000	----	1999-2000	----	
T09	1999-2000	----	1999-2000	1980-1990	USGS Station # 06479980
* T10	2000	----	2000	----	
T11	1999-2000	----	1999-2000	1982-1993	USGS Station # 06480400
T12	1999-2000	----	1999-2000	1981-1992	USGS Station # 06480650
T13	1999-2000	----	1999-2000	----	
T14	2000	----	2000	----	
* T15	2000-2001	----	2000-2001	----	
* T16	2000-2001	----	2000-2001	----	
T17	2000-2001	----	2000-2001	----	
T18	2000-2001	----	2000-2001	1984-1987 2001-2003	USGS Station # 06481480
* T19	2000-2001	----	2000-2001	----	
* T20	2000-2001	----	2000-2001	----	
T21	2000-2001	----	2000-2001	----	
* T22	2000-2001	----	2000-2001	----	
T23	2000-2001	----	----	1948-2002	USGS Station # 06481500
T24	2001	----	2001	----	
* T25	2000-2001	----	2000-2001	----	
* T26	2000-2001	----	2000-2001	----	
* T27	2000-2001	----	2000-2001	----	
T28	2000-2001	----	2000-2001	----	
T29	2000-2001	----	2000-2001	----	
T30	2000-2001	----	2000-2001	----	
T31	2000-2001	----	----	1965-1989 2001-2003	USGS Station # 06482610
T32	2000-2001	----	2000-2001	----	
T33	2000-2001	----	2000-2001	----	

* Numeric Standard Does Not Apply

Fecal Coliform Bacteria Load Duration Interval Graph Data

Site	Grab Data (May-Sep) Dates		Discharge Data Dates		Remarks
	EDWDD	DENR	EDWDD	USGS	
R01	2000	1999-2000	----	1980-2002	Discharge data derived from USGS Station # 06480000
R02	1999-2000	----	----	1980-2002	Discharge data derived from USGS Station # 06480000
R03	2000	1999-2000	----	1980-2002	Discharge data derived from USGS Station # 06480000
R04	1999-2000	----	----	1980-2002	Station #06480000
R05	1999-2000	1999-2000	----	1980-2002	Discharge data derived from USGS Station # 06480000
R06	1999-2000	----	----	1980-2002	Discharge data derived from USGS Station # 06481000
R07	1999-2000	----	----	1980-2002	Discharge data derived from USGS Station #06481000
R08	2000-2001	1999-2001	----	1980-2002	Station #06481000
R09	2000-2001	1999-2000	----	1980-2002	Discharge data derived from USGS Station #06481000
R10	2000-2001	----	----	1943-1960	Station #06482000
R11	2000-2001	1999-2001	----	1980-2002	Station #06482020
R12	2000-2001	1999-2001	----	1959-1972	Station #06482100
R13	2000-2001	----	----	1959-1972	Discharge data derived from USGS Station #06482100

Appendix BB.
Fecal Coliform Bacteria Reductions and Flow Duration Interval Graphs

Fecal Coliform Bacteria Reductions – River Sites

Load Duration Curves completed for each monitoring site using all hydrological zones, regardless of number of samples per zone. Values are in billions of colonies per day.

R01 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	80502	20987	6809	1962	280
Site Value	-----	2166	275	154	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

R02 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	85953	22408	7270	2095	299
Site Value	-----	7682	1016	208	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

R03 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	94054	24520	7955	2293	328
Site Value	-----	2525	1179	321	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

R04 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	98400	25600	8320	2400	343
Site Value	-----	2100	3759	853	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

R05 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	102232	26646	8604	2530	380
Site Value	-----	774	659	153	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

R06 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	128678	31255	10373	3610	731
Site Value	-----	9348	1310	8436	-----
% Reduction	-----	0	0	57	-----
% Reduction with MOS	-----	0	0	61	-----

R07 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	135115	32819	10892	3791	768
Site Value	-----	5887	1137	2058	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

R08 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	27563	6695	2222	773	157
Site Value	35059	1836	853	90	-----
% Reduction	21	0	0	0	-----
% Reduction with MOS	29	0	0	0	-----

R09 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	27783	6748	2240	779	158
Site Value	1687685	2561	558	404	-----
% Reduction	98	0	0	0	-----
% Reduction with MOS	99	0	0	0	-----

R10 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	13899	3602	920	313	35
Site Value	137332	59527	465	142	-----
% Reduction	90	94	0	0	-----
% Reduction with MOS	91	94	0	0	-----

----- Denotes no recorded samples

R11 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	35002	8809	2887	949	186
Site Value	130083	7145	1949	344	355
% Reduction					
	73	0	0	0	48
% Reduction with MOS					
	76	0	0	0	52

R12 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	13801	2613	842	333	166
Site Value	323537	1882	433	498	-----
% Reduction					
	96	0	0	33	-----
% Reduction with MOS					
	96	0	0	39	-----

R13 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	14534	2752	887	350	175
Site Value	266680	2386	534	1035	-----
% Reduction					
	95	0	0	66	-----
% Reduction with MOS					
	95	0	0	69	-----

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--- Denotes no recorded samples

Fecal Coliform Bacteria Reductions – Tributary Sites

Load Duration Curves completed for each monitoring site using all hydrological zones, regardless of number of samples per zone. Values are in billions of colonies per day.

T01 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	711	283	124	55	14
Site Value	374	90	-----	9	6
% Reduction	0	0	-----	0	0
% Reduction with MOS	0	0	-----	0	0

T02 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	2005	633	367	224	35
Site Value	1072	-----	556	81	7
% Reduction	0	-----	34	0	0
% Reduction with MOS	0	-----	40	0	0

T03 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	515	233	121	85	23
Site Value	329	16	-----	14	0.44
% Reduction	0	0	-----	0	0
% Reduction with MOS	0	0	-----	0	0

T04 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	1377	265	83	20	3
Site Value	9592	242	40	-----	-----
% Reduction	86	0	0	-----	-----
% Reduction with MOS	87	0	0	-----	-----

T05 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	1289	437	289	76	19
Site Value	5686	655	112	44	22
% Reduction	77	33	0	0	14
% Reduction with MOS	79	39	0	0	21

T06 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	1519	503	179	91	7
Site Value	594	142	190	50	-----
% Reduction	0	0	6	0	-----
% Reduction with MOS	0	0	14	0	-----

T07 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	865	258	103	47	16
Site Value	685	119	80	16	-----
% Reduction	0	0	0	0	-----
% Reduction with MOS	0	0	0	0	-----

No designated numeric standard

T08 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	1471	555	256	97	16
Site Value	16145	325	95	14	-----
% Reduction	91	0	0	0	-----
% Reduction with MOS	92	0	0	0	-----

No designated numeric standard

T09 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	10522	1958	685	166	22
Site Value	-----	194	382	87	-----
% Reduction	-----	0	0	0	-----
% Reduction with MOS	-----	0	0	0	-----

T10 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	1719	69	42	18	9
Site Value	20	45	-----	-----	-----
% Reduction	0	0	-----	-----	-----
% Reduction with MOS	0	0	-----	-----	-----

No designated numeric standard

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--- Denotes no recorded samples

T11 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	3866	597	302	152	42
Site Value	12457	545	151	-----	-----
% Reduction					
	69	0	0	-----	-----
% Reduction with MOS					
	72	0	0	-----	-----

T12 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	6338	1175	440	132	13
Site Value	48000	2380	380	27	-----
% Reduction					
	87	51	0	0	-----
% Reduction with MOS					
	88	55	0	0	-----

T13 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	590	136	37	17	0.37
Site Value	20320	110	-----	7	0.6
% Reduction					
	97	0	-----	0	38
% Reduction with MOS					
	97	0	-----	0	44

T14 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	942	311	65	16	2
Site Value	4226	194	20	5	-----
% Reduction					
	78	0	0	0	-----
% Reduction with MOS					
	80	0	0	0	-----

T15 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	8422	895	249	77	38
Site Value	21014	12076	177	214	7
% Reduction					
	60	93	0	64	0
% Reduction with MOS					
	64	93	0	67	0

No designated numeric standard

T16 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	9307	601	171	79	23
Site Value	-----	179	12	41	-----
% Reduction					
	-----	0	0	0	-----
% Reduction with MOS					
	-----	0	0	0	-----

No designated numeric standard

T17 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	22395	9699	6670	838	527
Site Value	25425	633	689	8453	-----
% Reduction					
	12	0	0	90	-----
% Reduction with MOS					
	20	0	0	91	-----

T18 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	15686	1517	303	64	23
Site Value	2719	1052	561	48546	-----
% Reduction					
	0	0	46	100	-----
% Reduction with MOS					
	0	0	51	100	-----

T19 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	6842	787	282	65	9
Site Value	702423	2282	-----	261	2
% Reduction					
	99	66	-----	75	0
% Reduction with MOS					
	99	69	-----	77	0

No designated numeric standard

T20 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	10852	953	242	170	120
Site Value	323921	649	428	136	41
% Reduction					
	97	0	43	0	0
% Reduction with MOS					
	97	0	49	0	0

No designated numeric standard

----- Denotes no recorded samples

T21 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	42206	8405	1430	1187	995
Site Value	361301	2670	288	-----	28
% Reduction					
	88	0	0	-----	0
% Reduction with MOS					
	89	0	0	-----	0

T22 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	8312	435	58	40	36
Site Value	244965	461	17	-----	11
% Reduction					
	97	6	0	-----	0
% Reduction with MOS					
	97	14	0	-----	0

No designated numeric standard

T23 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	22150	2496	538	108	19
Site Value	1082846	1002	9	6	-----
% Reduction					
	98	0	0	0	-----
% Reduction with MOS					
	98	0	0	0	-----

T24 - 2000 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	13624	4141	1272	195	151
Site Value	186858	1868	-----	7	0.41
% Reduction					
	93	0	-----	0	0
% Reduction with MOS					
	93	0	-----	0	0

T25 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	408	110	29	17	15
Site Value	29519	268	65	184	163
% Reduction					
	99	59	55	91	91
% Reduction with MOS					
	99	63	59	92	92

No designated numeric standard

T26 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	2424	568	29	8	0.66
Site Value	1641	20779	49	81	8
% Reduction					
	0	97	41	90	92
% Reduction with MOS					
	0	98	46	91	93

No designated numeric standard

T27 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	2651	337	163	75	49
Site Value	982246	49479	782	401	378
% Reduction					
	100	99	79	81	87
% Reduction with MOS					
	100	99	81	83	88

No designated numeric standard

T28 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	3733	479	124	80	47
Site Value	18187	6054	479	784	207
% Reduction					
	79	92	74	90	77
% Reduction with MOS					
	81	93	76	91	79

T29 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	6119	702	389	357	329
Site Value	17781	3813	1025	311	1227
% Reduction					
	66	82	62	0	73
% Reduction with MOS					
	69	83	65	0	76

T30 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	6201	905	493	148	132
Site Value	132947	842	10980	756	-----
% Reduction					
	95	0	96	80	-----
% Reduction with MOS					
	96	0	96	82	-----

----- Denotes no recorded samples

T31 - 400 cfu/100mL

Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	4885	685	245	89	29
Site Value	653761	3475	778	659	-----
% Reduction					
	99	80	69	86	-----
% Reduction with MOS					
	99	82	71	88	-----

T32 - 2000 cfu/100mL

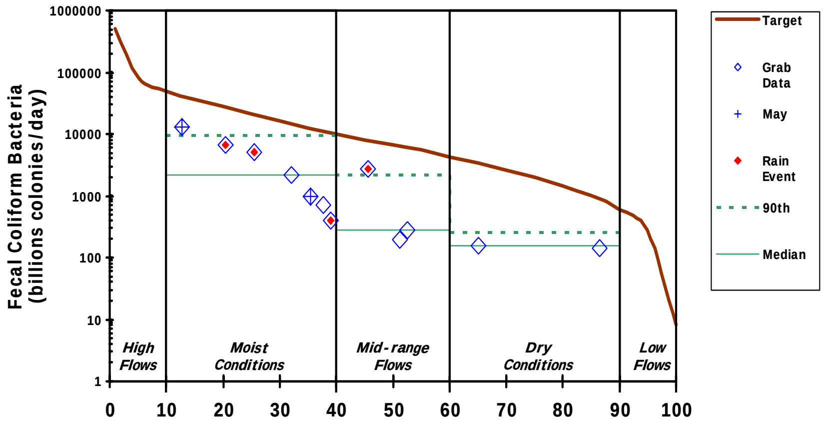
Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	7991	3563	1664	1204	669
Site Value	331811	43274	506	122	98
% Reduction					
	98	92	0	0	0
% Reduction with MOS					
	98	93	0	0	0

T33 - 2000 cfu/100mL

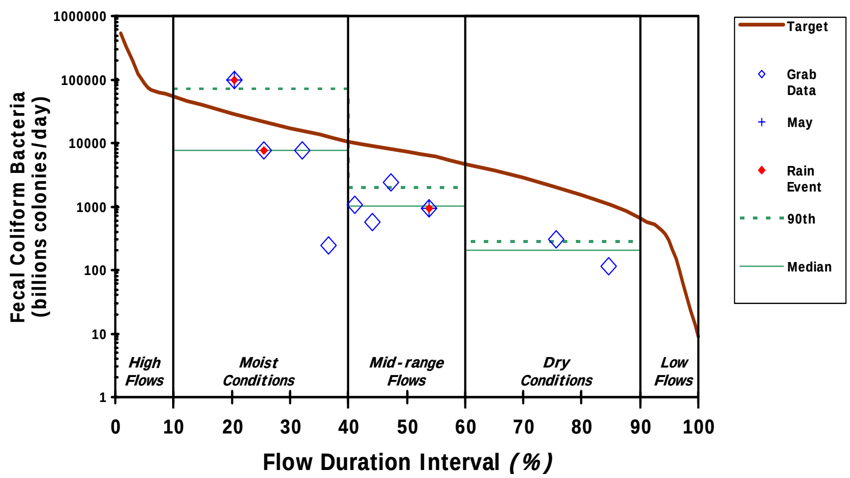
Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
Target	28032	6061	1249	603	137
Site Value	61012	4193	636	280	85
% Reduction					
	54	0	0	0	0
% Reduction with MOS					
	58	0	0	0	0

----- Denotes no recorded samples

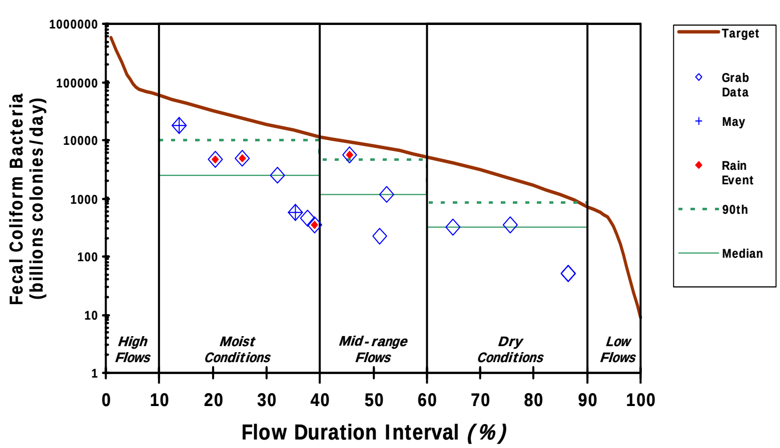
R01 - Big Sioux River near Brookings, SD



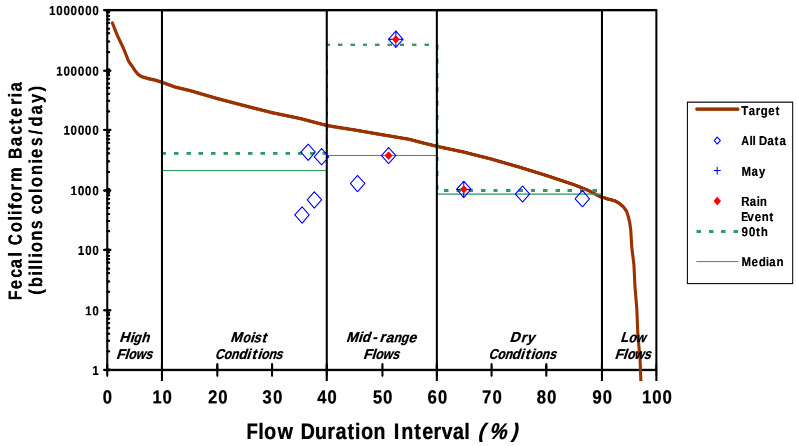
R02 - Big Sioux River at Sinai Road, Brookings, SD



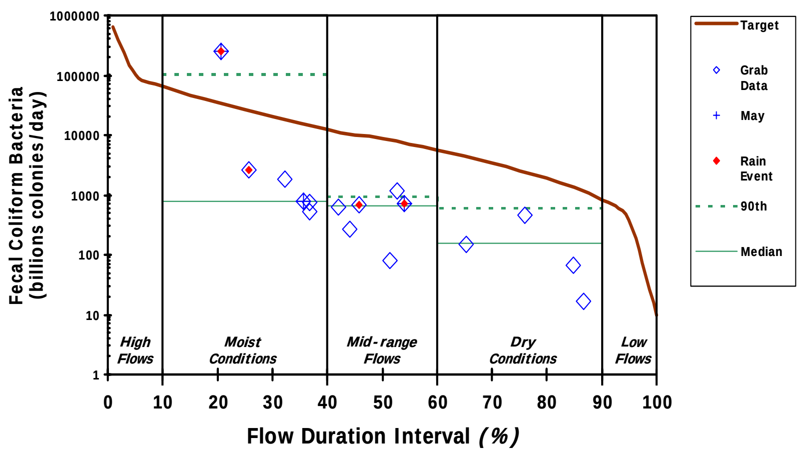
R03 - Big Sioux River at Hwy 77, Brookings SD



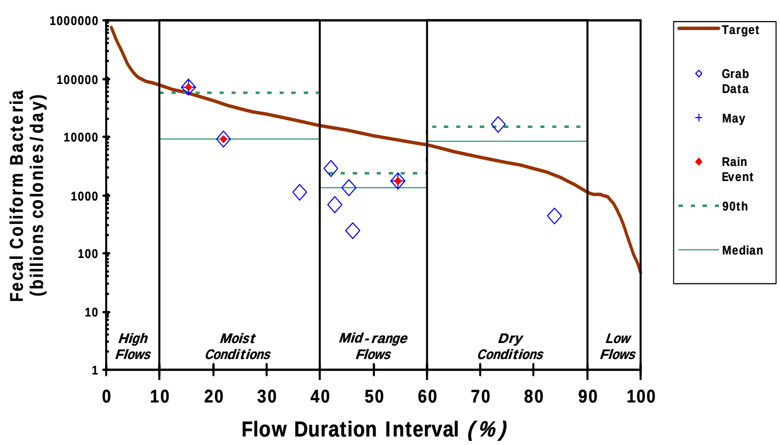
R04 - Big Sioux River at Brookings, SD



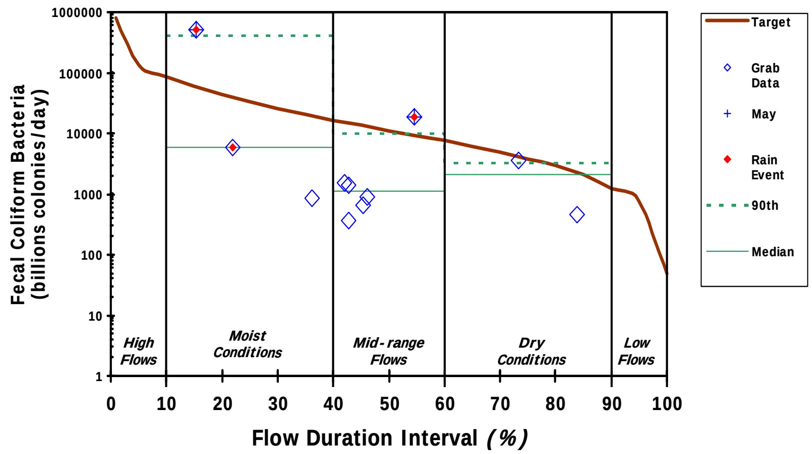
R05 - Big Sioux River near Flandreau, SD



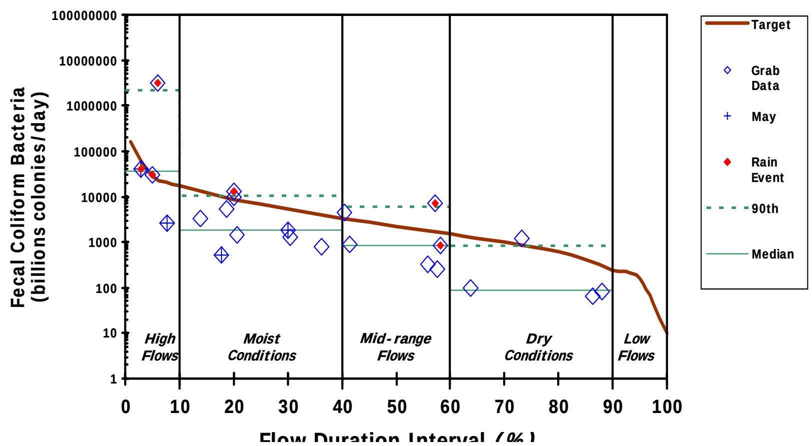
R06 - Big Sioux River at Egan, SD



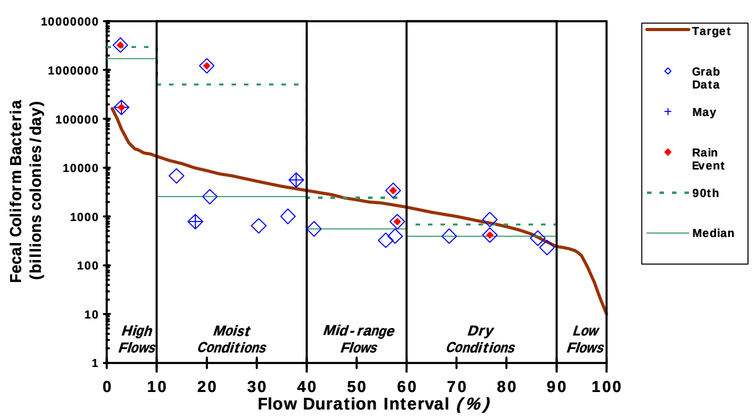
R07 - Big Sioux River at Trent, SD



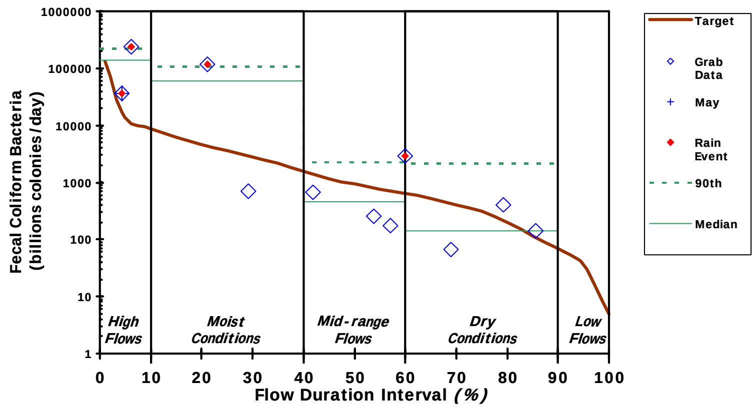
R08 - Big Sioux River at USGS Dell Rapids, SD



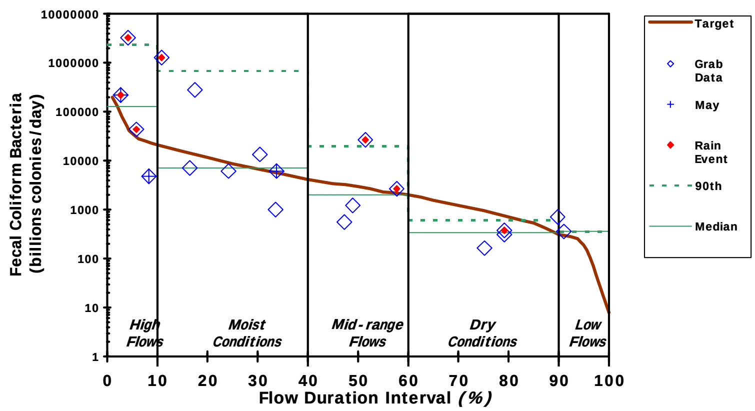
R09 - Big Sioux River at Hwy 38A, Sioux Falls SD



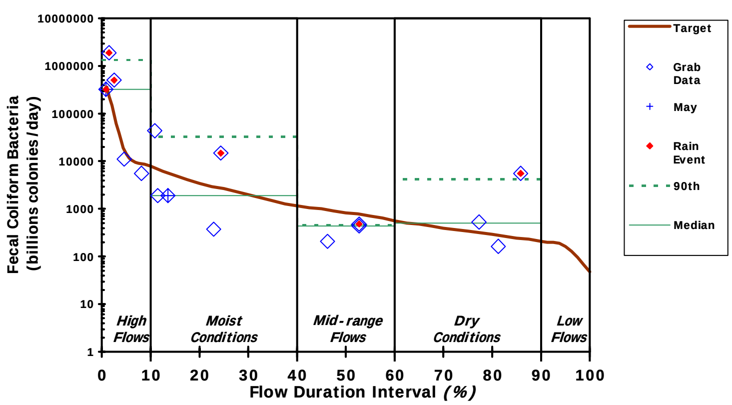
R10 - Big Sioux River at Western Avenue, Sioux Falls SD



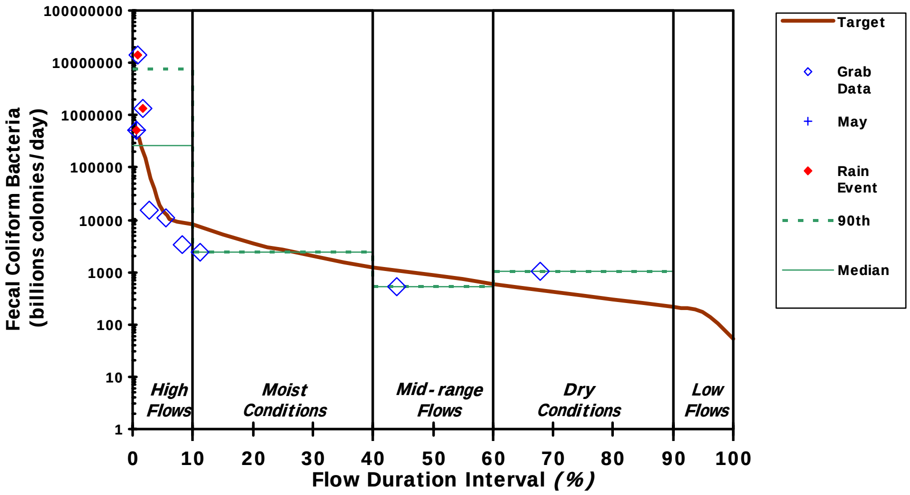
R11 - Big Sioux River at USGS North Cliff Avenue, Sioux Falls, SD



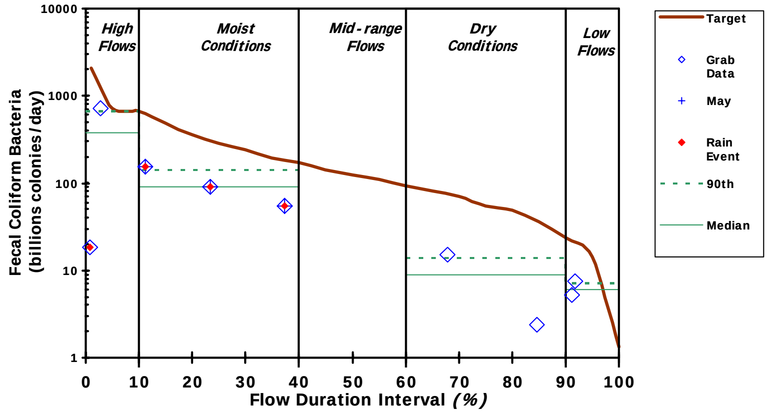
R12 - Big Sioux River at Brandon, SD



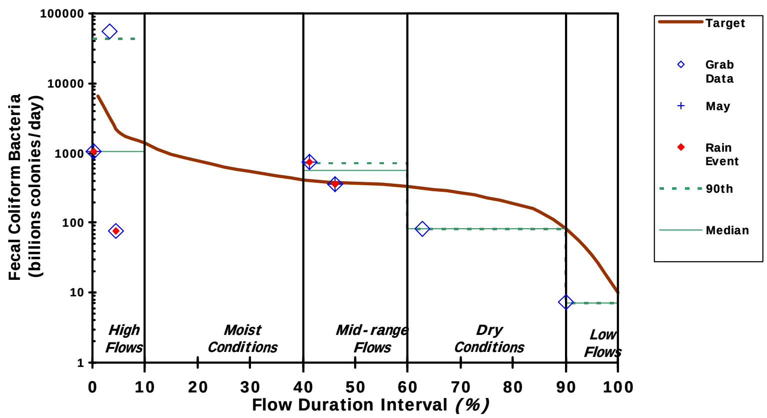
R13 - Big Sioux River at Gitchie Manitou, Sioux Falls, SD



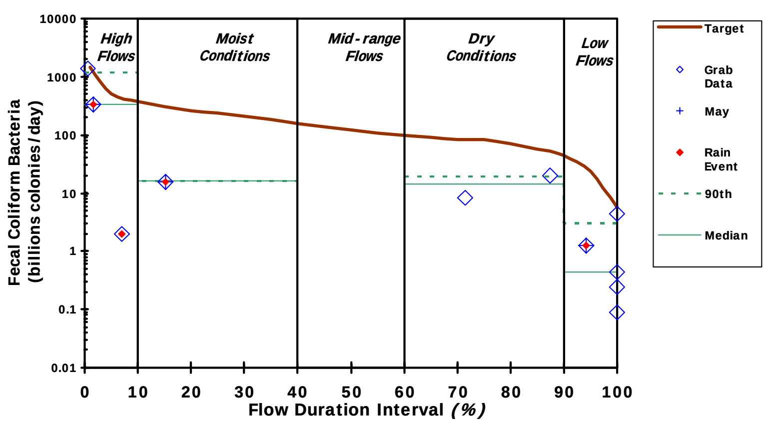
T01 – North Deer Creek (Upper) near Bruce, SD



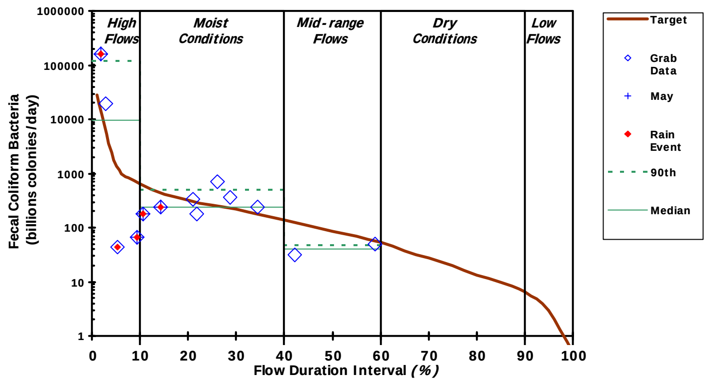
T02 – North Deer Creek (Lower) at Brookings, SD



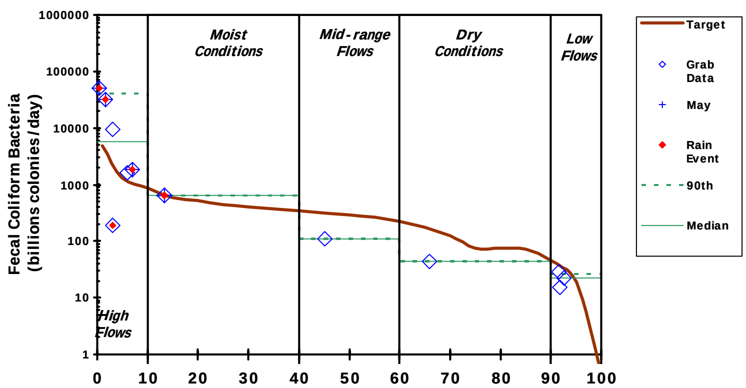
T03 – Six Mile Creek (Upper) at White, SD



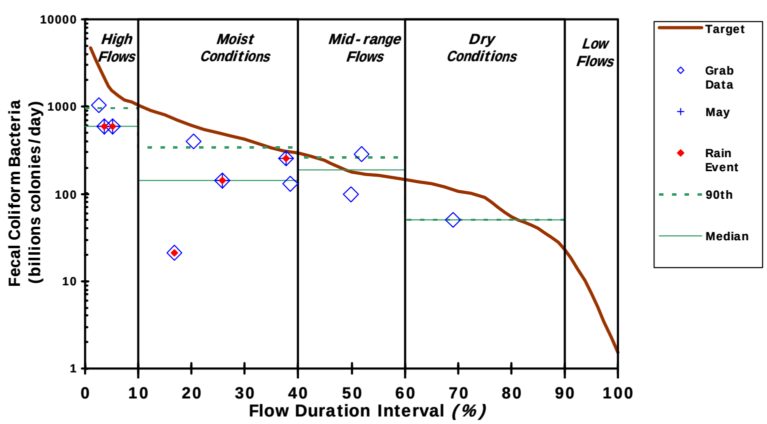
T04 – Six Mile Creek (Middle) above Brookings, SD



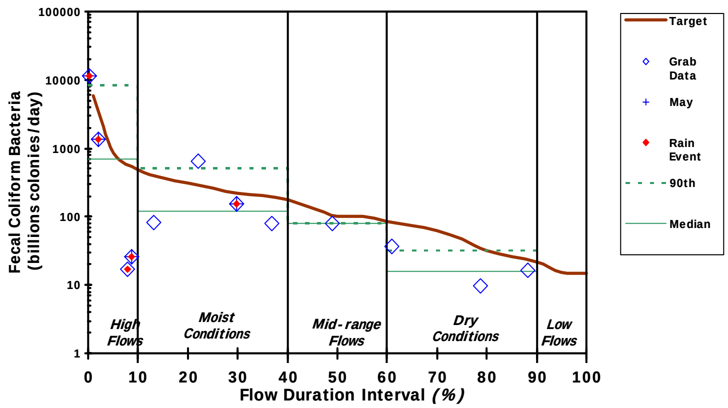
T05 – Six Mile Creek (Lower) below Brookings, SD



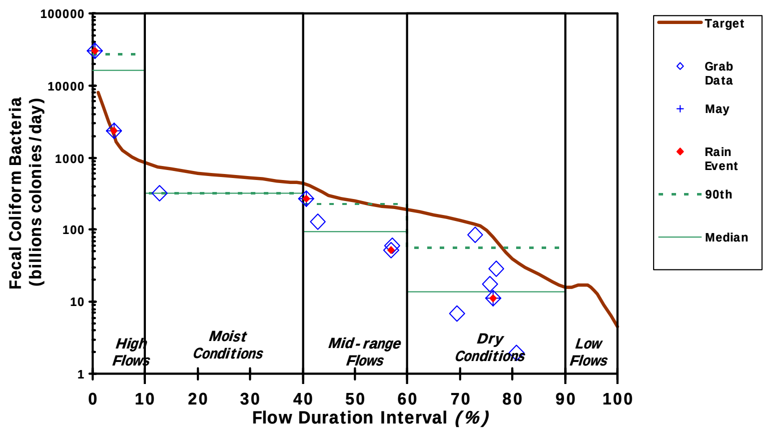
T06 – Deer Creek at Brookings, SD



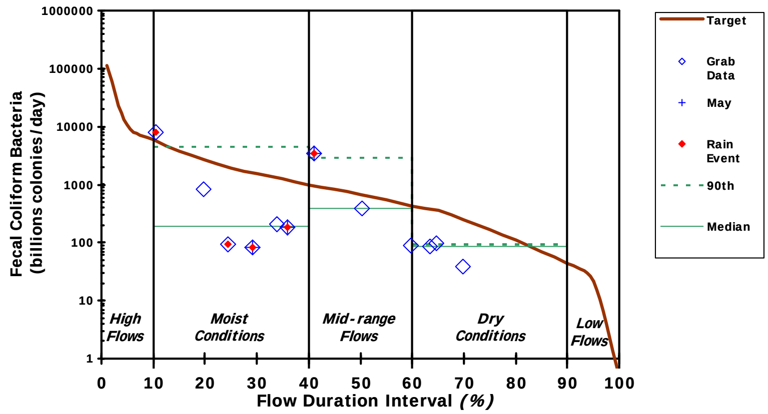
T07 – Medary Creek (Upper) at Elkton, SD



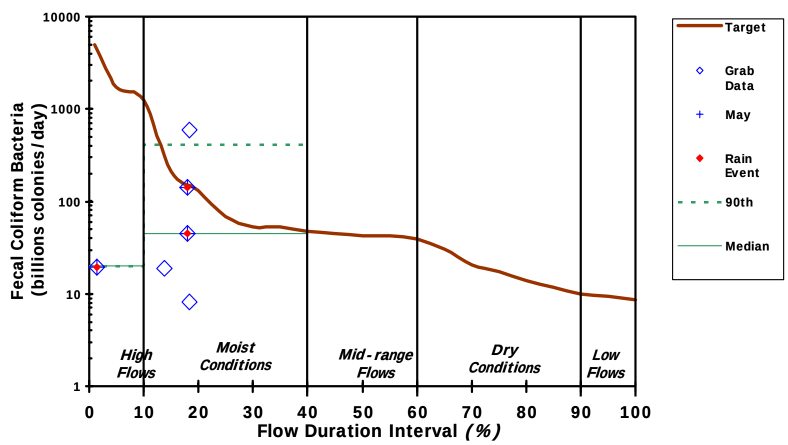
T08 – Medary Creek (Middle) near Aurora, SD



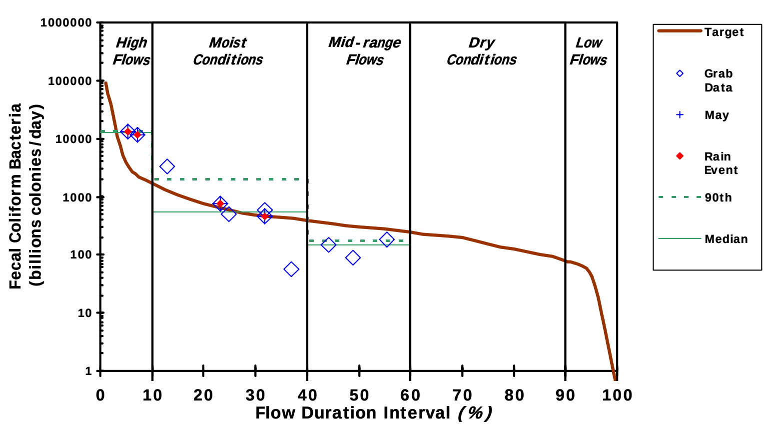
T09 – Medary Creek (Lower) near Brookings, SD



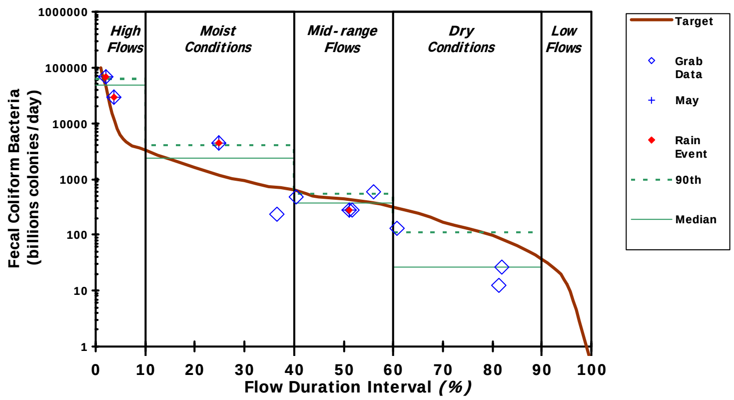
T10 – Lake Campbell Outlet, SD



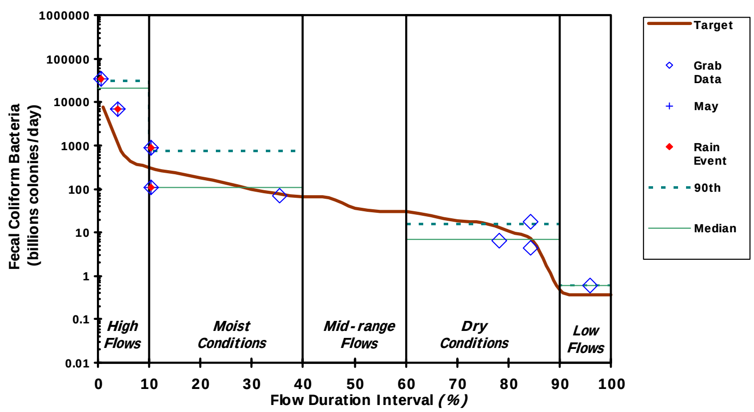
T11 – Spring Creek near Flandreau, SD



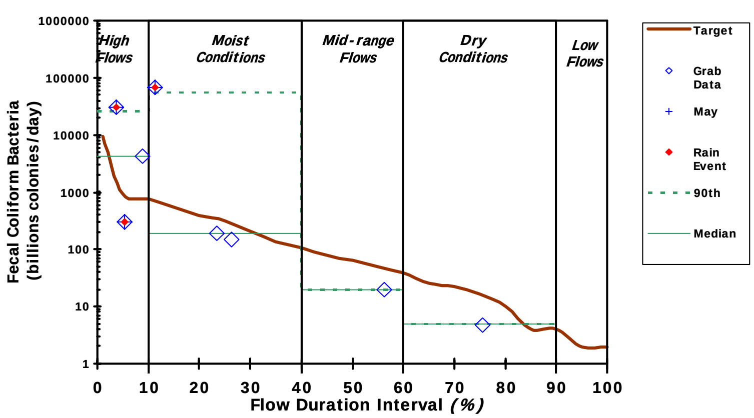
T12 – Flandreau Creek near Flandreau, SD



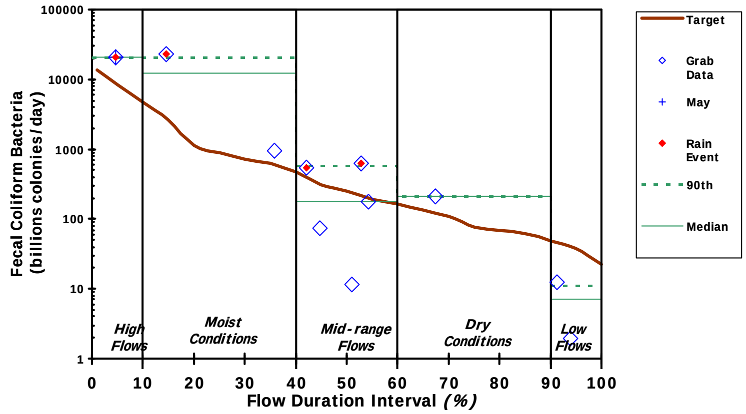
T13 – Jack Moore Creek near Egan, SD



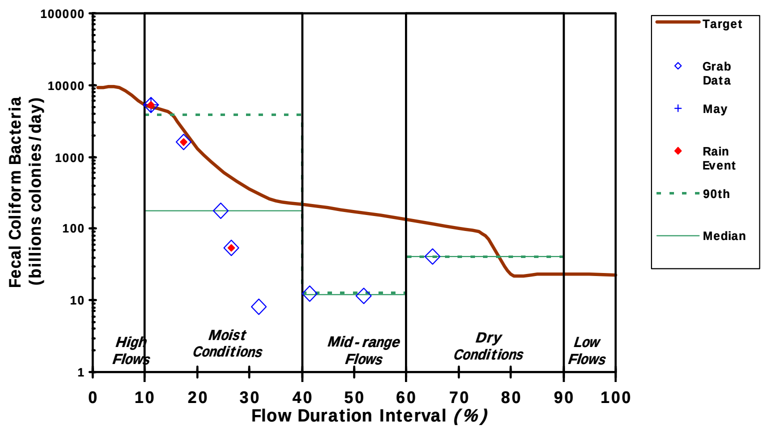
T14 – Bachelor Creek near Trent, SD



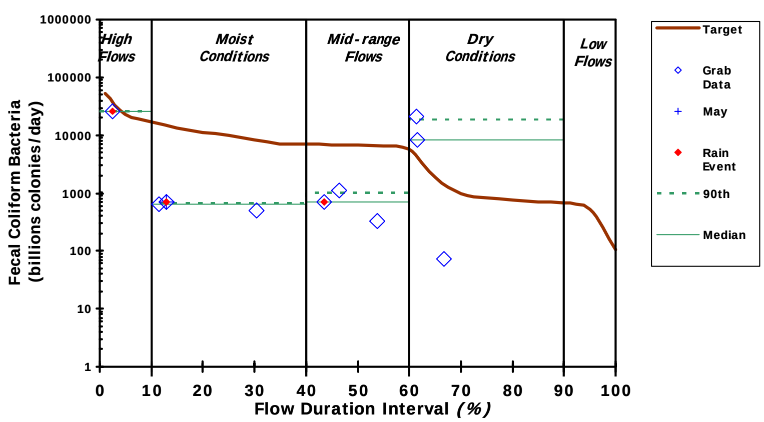
T15 – North Buffalo Creek near Chester, SD



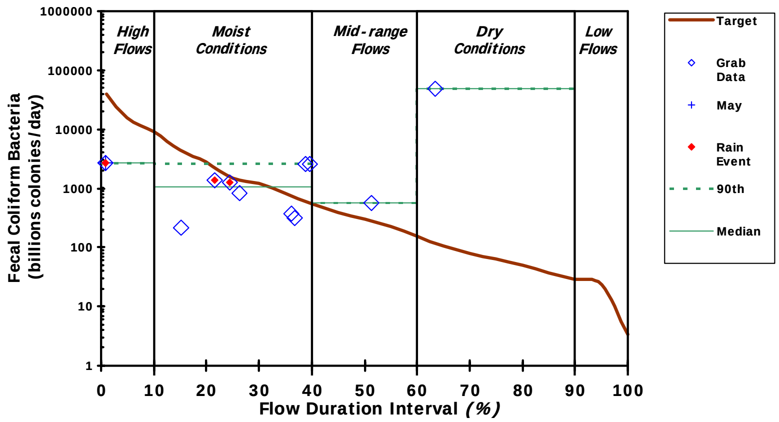
T16 – Buffalo Creek near Chester, SD



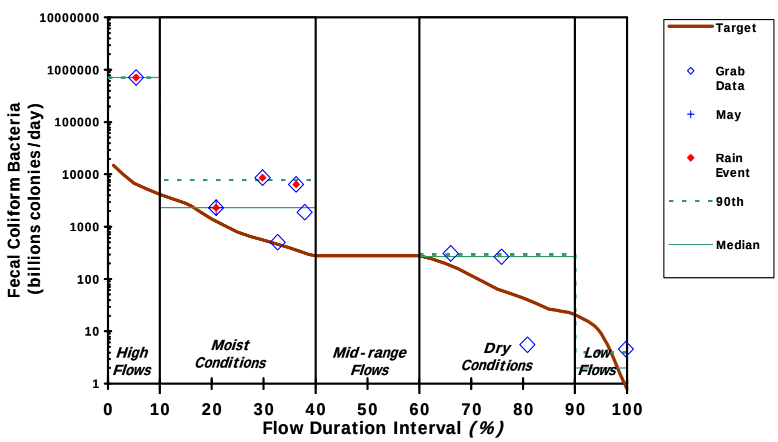
T17 – Brant Lake Outlet, SD



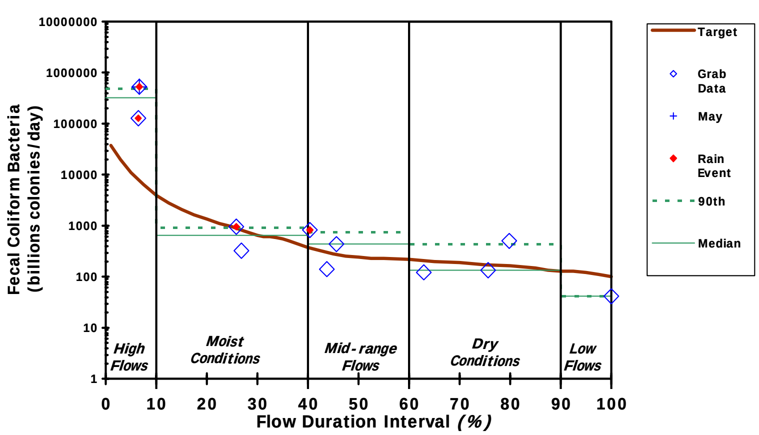
T18 – Skunk Creek near Chester, SD



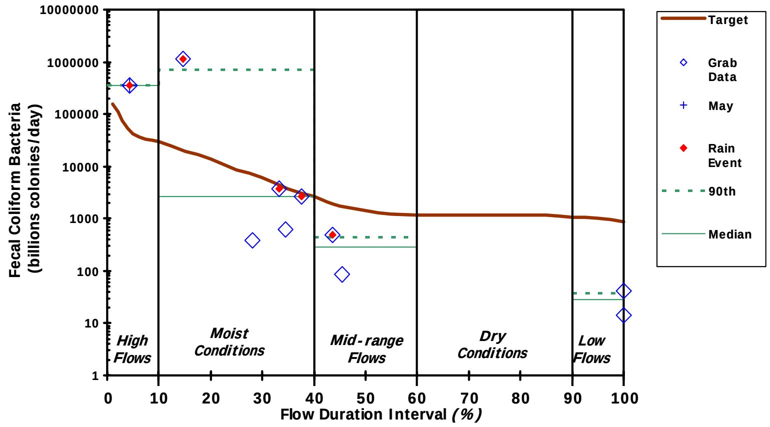
T19 – Colton Creek near Hartford, SD



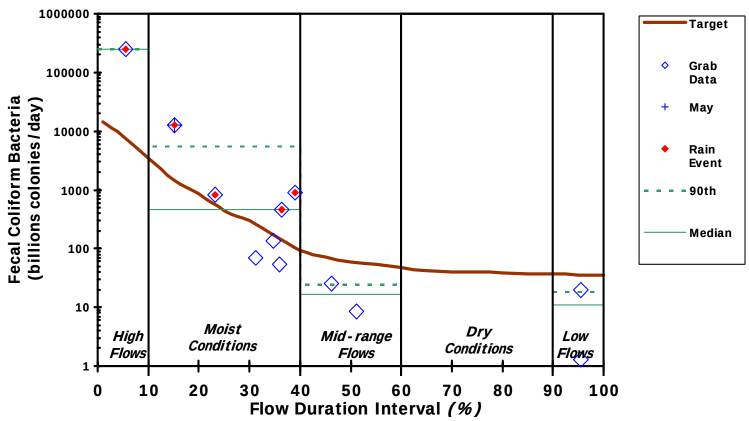
T20 – West Branch Skunk Creek near Hartford, SD



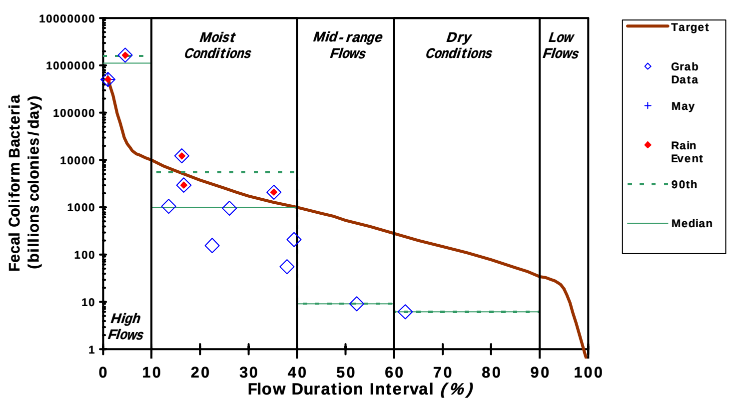
T21 – Skunk Creek (Middle) near Sioux Falls, SD



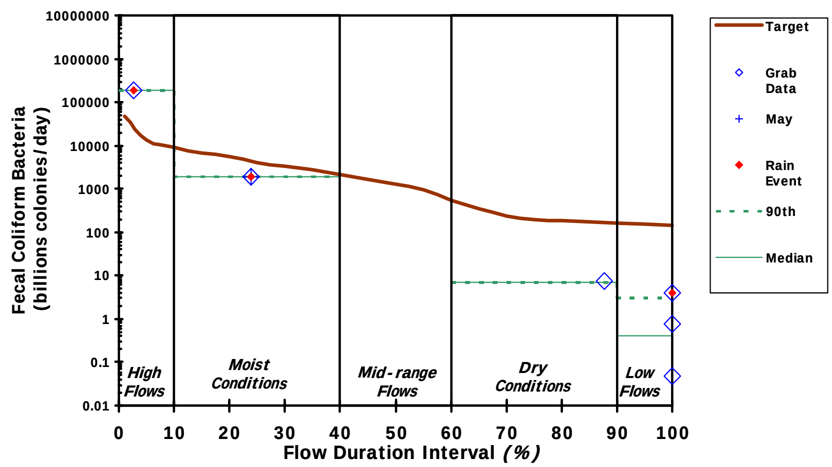
T22 – Willow Creek near Sioux Falls, SD



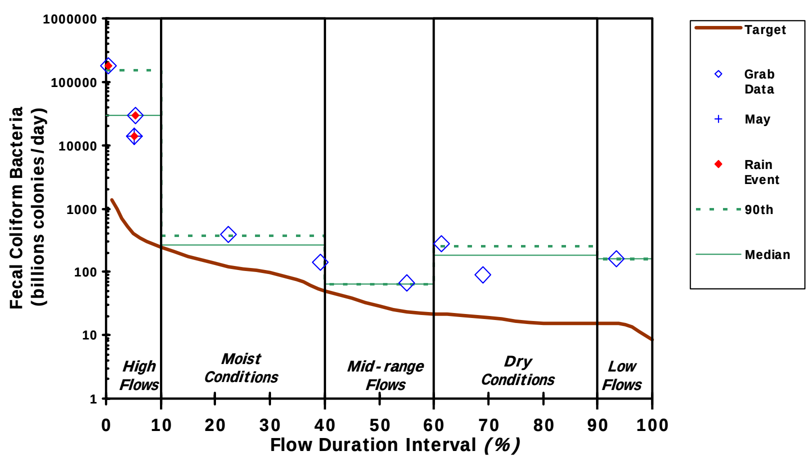
T23 – Skunk Creek at Sioux Falls, SD



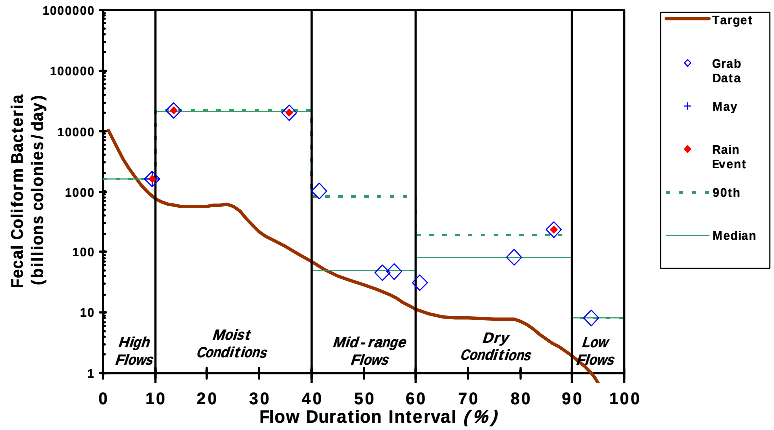
T24 – Silver Creek near Renner, SD



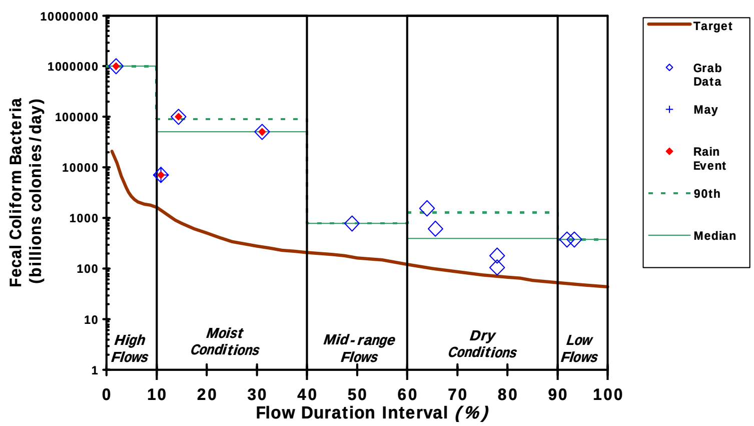
T25 – Slip-Up Creek near Renner, SD



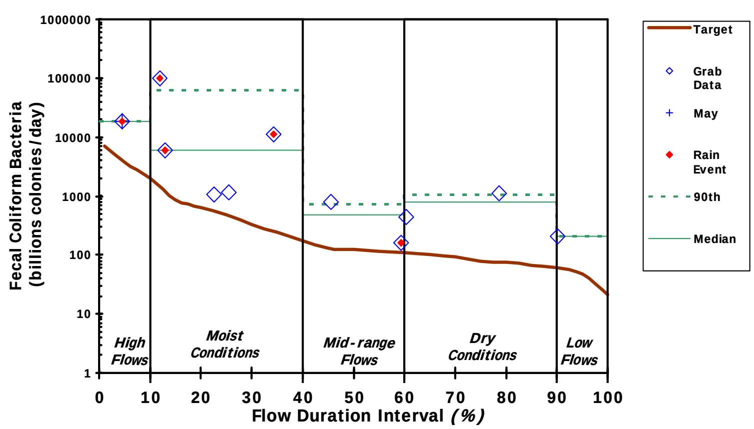
T26 – West Pipestone Creek (Upper) near Sherman, SD



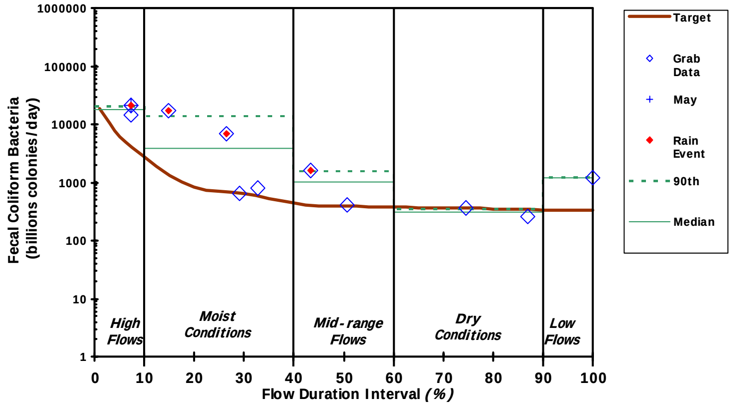
T27 – West Pipestone Creek (Lower) near Corson, SD



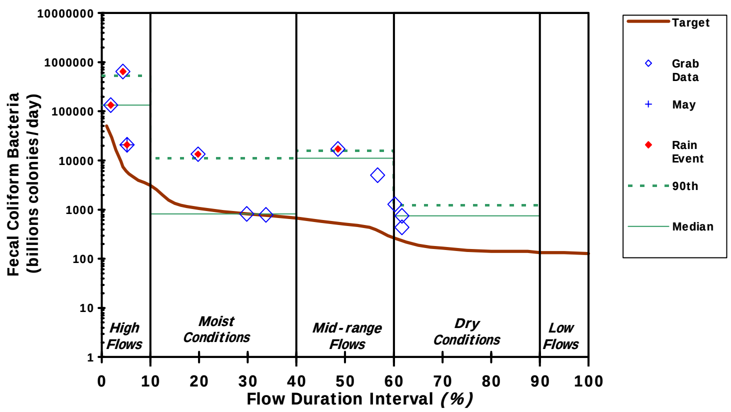
T28 – Pipestone Creek (Upper) near Egan, SD



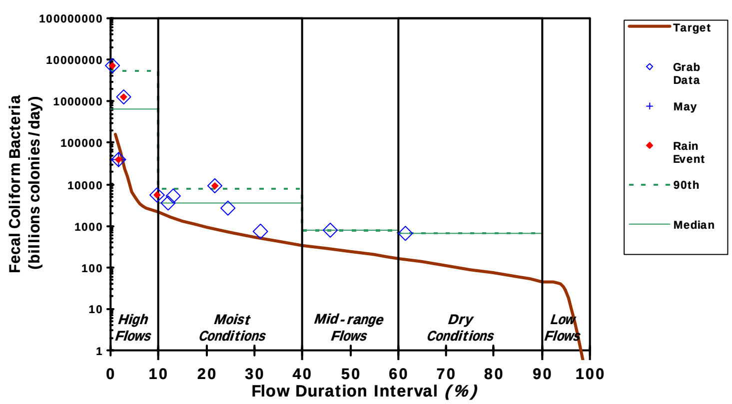
T29 – Pipestone Creek (Lower) near Sherman, SD



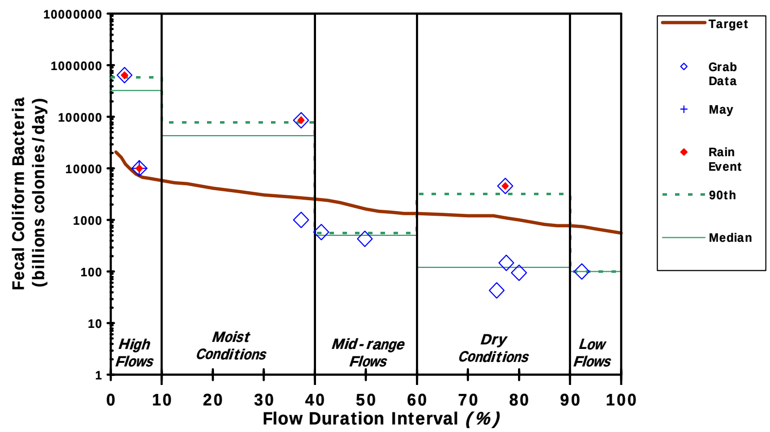
T30 – Split Rock Creek (Upper) near Sherman, SD



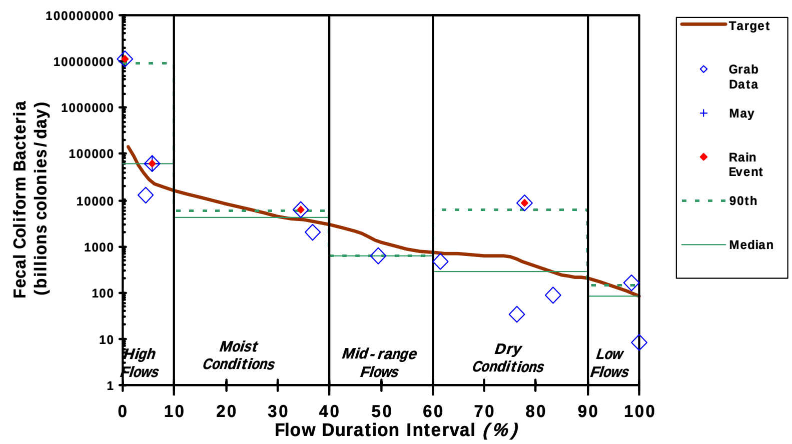
T31 – Split Rock Creek at Corson, SD



T32 – Beaver Creek (Upper) near Valley Springs, SD



T33 – Beaver Creek (Lower) near Brandon, SD



Appendix CC.
Methodology of the AGNPS Feedlot Model

Feedlot Inventory for the Central Big Sioux River Watershed Assessment Project

1. Methodology

1.1. Introduction

Objectives outlined in the project summary were to document sources of nonpoint source pollution in the Central Big Sioux River Watershed to drive a watershed implementation project directed towards improving water quality. Preliminary water quality sampling suggested that impairments to the watershed were in the form of sediment born material and fecal coliform bacteria. Based on this information, the Brookings County Conservation District drove all township, county, state and interstate roads within the watershed boundaries to locate Animal Feeding Operations (AFOs) and other potential sources of impairments. Since the landuse was largely agricultural, efforts were focused towards un-regulated AFOs which could be a potential source of organic material and fecal coliform bacteria loading during runoff events. Due to the shear size of the watershed (approximately 1.2 million acres), variability of pastured cattle along stream drainages and manure application became too daunting of a task to inventory, so locating and documentation of livestock operations that confined animals became the primary goal. Methods used in the Central Big Sioux River Watershed Assessment to determine loadings and reductions of fecal coliform bacteria, involved the use of hydrologic zones and flow/load duration intervals. These methods could serve as an integrated measure of runoff between confined livestock operations, manure application and pastured livestock along stream corridors. During large rainfall events, (> 2 inches/24 hours), which is a common occurrence for the area, organic material and fecal coliform bacteria found in the water samples could be the result of all three: confined operations, pastured livestock along stream corridors and manure application. During dry periods, loading from confined operations would be minimal as compared to the potential input from pastured livestock with access to streams and poorly placed manure applications. With this in mind, a key to distinguish between the loading potential of livestock confinement operations vs. pastured livestock and land based manure applications lay in the water quality samples with their respective rainfall data.

1.2. Watershed Delineation

The watershed map was formulated with a starting point of the watershed located where the Big Sioux River intersected highway 14 between Brookings and Volga and an endpoint at the confluence of Beaver Creek south of Brandon, South Dakota. Watershed boundaries were delineated using 1:42,000 topographic maps and ground truthing. Boundary lines were transferred to Arc-View, a computer based software program, to enable future compilation and manipulation of database information spatially. The watershed was later broken down by the GAP Analysis Lab at South Dakota State University into sub-watersheds , called land management units (LMUs), using Arc-Info Spatial Analyst with Digital Elevation Models (DEM's) based on the location of monitoring sites and the area that drained into them (See Figure 1). Other layers for the Arc-View database included: Digital Ortho-Quadrangles (DOQ's), Streams, Roads, Soils, Township Boundaries and Section lines. The watershed encompassed approximately 1.2 million acres of predominantly agricultural land in southeast South Dakota (See Figure 2).

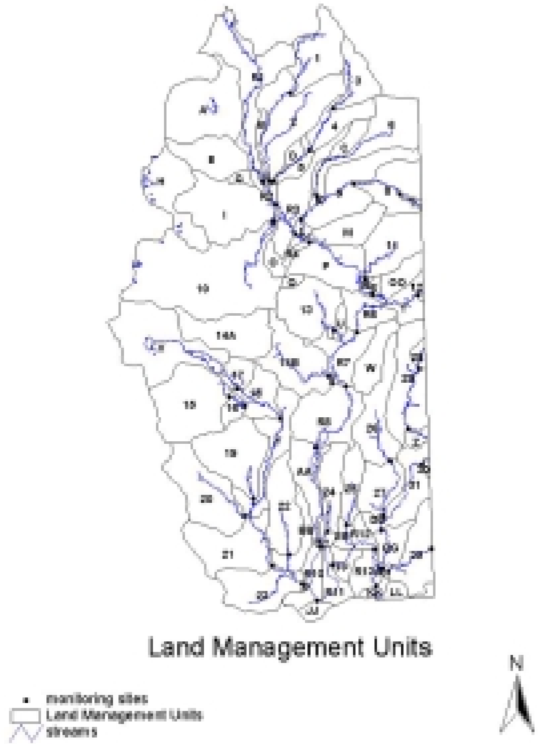


Figure 1. Central Big Sioux River Watershed Separated into Land Management Units (LMUs)

Central Big Sioux River Watershed Location Map

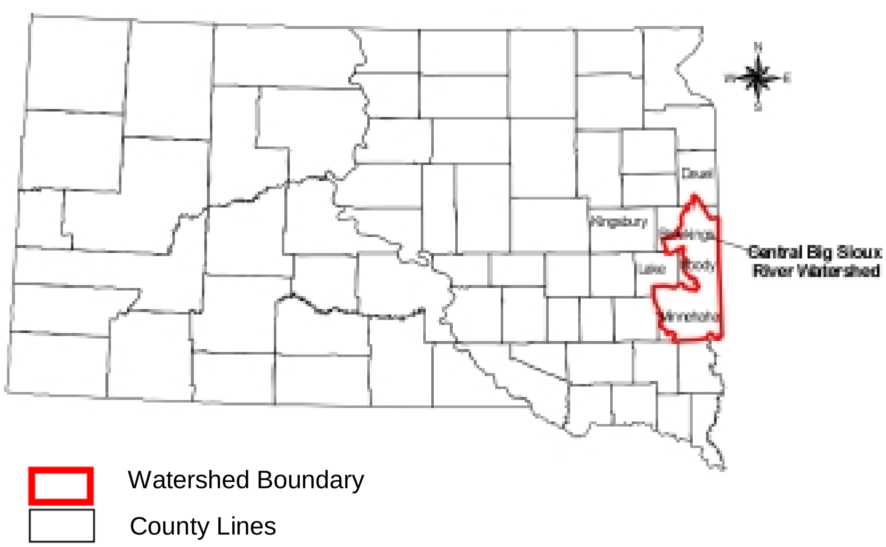


Figure 2. Central Big Sioux River Watershed Location Map

1.3. Feedlot Model

All livestock operations within watershed boundaries were highlighted on copies of the latest plat book directories for future contacts. Arc-View was then used to produce an enlarged image (usually on a 1:1,400 scale) of all highlighted operations from 1992 DOQ's that were donated to the project from the Natural Resource Conservation Service (NRCS). These enlarged photos would later serve as templates and data sheets for collection of the operations' information (See Figure 3). Each producer was given a chance to volunteer information about their operation through direct visits, phone calls or letters left in their doors. If a producer was willing to volunteer information for the assessment, they were shown the DOQ printout and asked for data to satisfy inputs for Agricultural Non-Point Source (AGNPS) pollution model's feedlot module. Information collected from each producer is shown in Table 1.

Figure 3. Digital Ortho-Quadrangles used for Operator Surveys

Feeding operations with potential for runoff were assessed using the AGNPS feedlot module. Operations confining <40 animal units (AU's) and exhibiting no potential for runoff were excluded from the model and simply marked on Arc-View as a green dot. There were a few operations confining <40 AU's that were included in the investigation only because they were located within a short distance from a major tributary or the Big Sioux River itself and exhibited a potential to have runoff occur. Any feeding operation with >40 AU's was modeled using AGNPS. Extra effort was made to contact and interview every producer with a livestock operation personally in the watershed in order to collect good quality information. Gaining trust with producers and access to their operations made this possible. 828 operations were evaluated in the watershed for potential to contribute runoff to surface waters. Of the 828 operations, 712 animal feeding operations were assessed using AGNPS Feedlot Module. During our investigation, 25 of the operations visited fit the criteria for a Concentrated Animal Feeding Operation (CAFO). Large CAFO's that were permitted or had a waste system in place were inventoried, and labeled in the database, but were not subjected to the feedlot model itself. Most of the CAFO's had some type of waste storage system in place, and some had obtained coverage under the general permit.

A portion of the operations believed to be CAFO's though did not have any waste storage or coverage under the general permit.

Table 1. Information Collected From Each Producer

ID	Area	Acres	Animal	Number	Animal2	Number2	Code	Waste System	Months	Buffer	Buffer
1	10544.9	2.6	BEEF CATTLE	40		0	T1NDCK	NONE	0	0	
3	13461.9	3.3	BEEF CATTLE	180		0	T1NDCK	NONE	0	0	
4	8563.8	2.1	BEEF CATTLE	150		0	T1NDCK	NONE	0	0	
6	10335.7	2.6	BEEF CATTLE	100	DAIRY	50	T1NDCK	NONE	0	300	
7	3923.6	1.0	SOWS	120		0	T1NDCK	NONE	0	0	
9	8941.7	2.2	BEEF CATTLE	100		0	T1NDCK	NONE	0	0	
12	11324.7	2.8	BEEF CATTLE	80		0	T1NDCK	NONE	0	0	
16	24571.4	6.1	BEEF CATTLE	150		0	T1NDCK	NONE	0	0	
20	28591.4	7.1	BEEF CATTLE	200		0	T4SXMCK	NONE	12	50	PASTURE
21	22427.3	5.5	BEEF CATTLE	400		0	T3SXMCK	NONE	0	0	
21	18234.2	4.5	BEEF CATTLE	250		0	T3SXMCK	NONE	0	0	
22	16959.6	4.2	BEEF CATTLE	300		0	T3SXMCK	NONE	0	0	
26	12447.3	3.1	BUFFALO	50		0	T3SXMCK	NONE	0	450	
1000	10850.9	2.7	DAIRY CATTLE	120		0	T1NDCK	NONE	0	0	

1.4. Arc-View Model

Geographic Information Systems (GIS) ARC-View was then used to create a watershed distribution map of all operations with their respective information. Four shape files were created to handle the data from the assessments for each of the operations. The first shape file created was the Operator theme (See Table 2). It contained location information as well as summary information that were added back to the theme table after the AGNPS feedlot module was run for all of the operations. The second shape file created was the feedlot theme. It was used to capture the size and number of head each lot contained for each operation. The third shape file was the roof theme. It allowed us to measure the area of roof involved in adding water to the feedlot that AGNPS required as an input. The last shape file was the Watershed theme. This theme was used to digitize the area and landuse type that comprised the 2a and 3a areas that were also inputs needed in the AGNPS module (See Figure 4).

Table 2. Table Used to Create the Operator Theme in ArcView

ID	Distance	LMU	Code	PO4 (ppm)	COD (ppm)	PO4 (lbs)	COD (lbs)	SURFACER	GROUNDR	CAFO
1	16295.4	1	T1NDCK	13.0	689.7	37.5	1987.5	39	1	NO
2	15896.2	1	T1NDCK	18.4	974.0	153.3	8113.1	60	1	NO
3	15656.0	1	T1NDCK	46.0	2432.4	187.2	9909.4	61	1	NO
4	14799.1	1	T1NDCK	60.1	3184.0	140.5	7436.1	56	1	NO
5	11833.9	1	T1NDCK	85.0	4500.0	135.8	7189.3	54	1	NO
6	9110.4	1	T1NDCK	19.2	1214.6	57.0	3609.4	47	1	NO
7	8315.9	1	T1NDCK	28.4	946.4	31.8	1061.2	29	2	NO
8	10646.6	3	T3SXMCK	11.4	590.0	123.9	6436.9	58	1	NO
9	4404.9	1	T1NDCK	57.7	3054.3	131.5	6959.7	55	1	NO
10	21366.8	2	T2NDCK	8.9	1412.8	11.2	1786.0	36	3	NO
11	21896.0	2	T2NDCK	85.0	4500.0	248.7	13163.7	264	2	NO
12	20032.4	2	T2NDCK	36.4	1928.6	132.2	7000.0	56	2	NO
13	19321.8	2	T2NDCK	2.7	430.4	15.3	2429.0	43	2	NO
14	18128.7	2	T2NDCK	54.8	2900.7	209.4	11077.1	62	2	NO
15	18175.1	2	T2NDCK	51.2	2692.8	194.1	10210.1	61	2	NO
16	22194.9	2	T2NDCK	9.9	463.9	55.1	2571.3	44	1	NO

ArcView Image of Digitized Feedlots

Figure 4. ArcView Image of Digitized Feedlots

Figure 5 shows a simple drawing that illustrates the basic interactions that needed to be taken in consideration when gathering information for the AGNPS feedlot module (USDA AGNPS Feedlot Manual). After digitizing each operation for the operator location; feedlot locations and size; roof area; watershed landuse and size; all required inputs were satisfied for the AGNPS feedlot module.

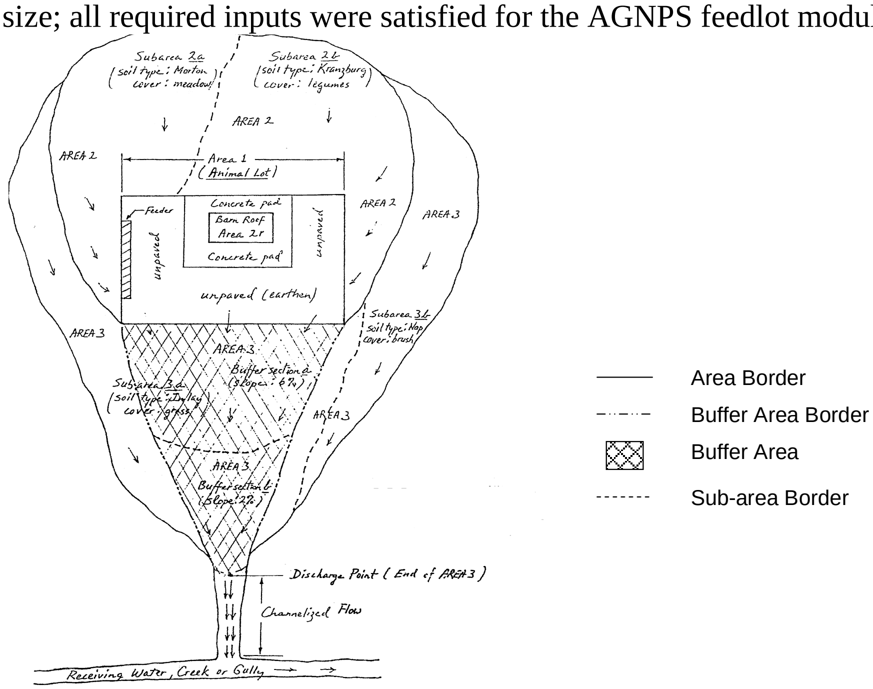


Figure 5. Example of an Animal Lot with Surrounding Watershed

1.5. Combining Arc-View and the AGNPS Feedlot Module

Data was then entered separately for each operation from the Arc-View themes into the AGNPS feedlot module. The module was run to simulate a 25 year 24 hour rainstorm event that was currently a requirement of the general permit for construction of waste storage facilities. Some of the inputs were indexes, so they were standardized to simplify data entry with the thinking that differences in the output would be caused by interactions taking place for each operation's unique situation. After all of the operations were run through AGNPS, the output data was entered back into the operator theme to allow a means of differentiating between feeding operations with a high potential to have runoff from those with little or no potential. AGNPS surface ratings for runoff potential ranged from 0 – 102 for the facilities assessed. AGNPS Phosphorus loading potentials ranged from 0.0 lbs. – 1,574 lbs. for any single animal feeding operation. By using Arc-View, a watershed map could easily be made with feedlots geo-referenced and categorized by a graduated color scheme representing various potential to have runoff occurring. Operations exhibiting low potential were color coded green while intermediate potential sites were given a light green or yellow color. Medium high to high potential operations were color coded orange and red (See Figure 6). By coding each operation with a unique value representative of the monitoring site that it eventually flowed to, allowed us to count the number of feedlots in a particular sub-watershed and compare it to water quality data from that point. Depending on runoff potentials of the feedlots affecting any monitoring site, we were able to make a prediction of which sites should exhibit good or poor water quality downstream.

The joining of the AGNPS feedlot module and GIS feedlot databases was used to create a comprehensive watershed model that could simulate various scenarios in order to better predict interactions taking place in the watershed. Managers could use the model as a tool to test "what if" circumstances and make changes to get more desirable outcomes. While working with producers during the implementation phase, simulations could be run to see what effects one might achieve by planning for certain practices (e.g. filters, sediment basins or complete waste management systems). Implementation of best management practices in high pollution potential areas could be the key to improving water quality in the Central Big Sioux River Watershed.

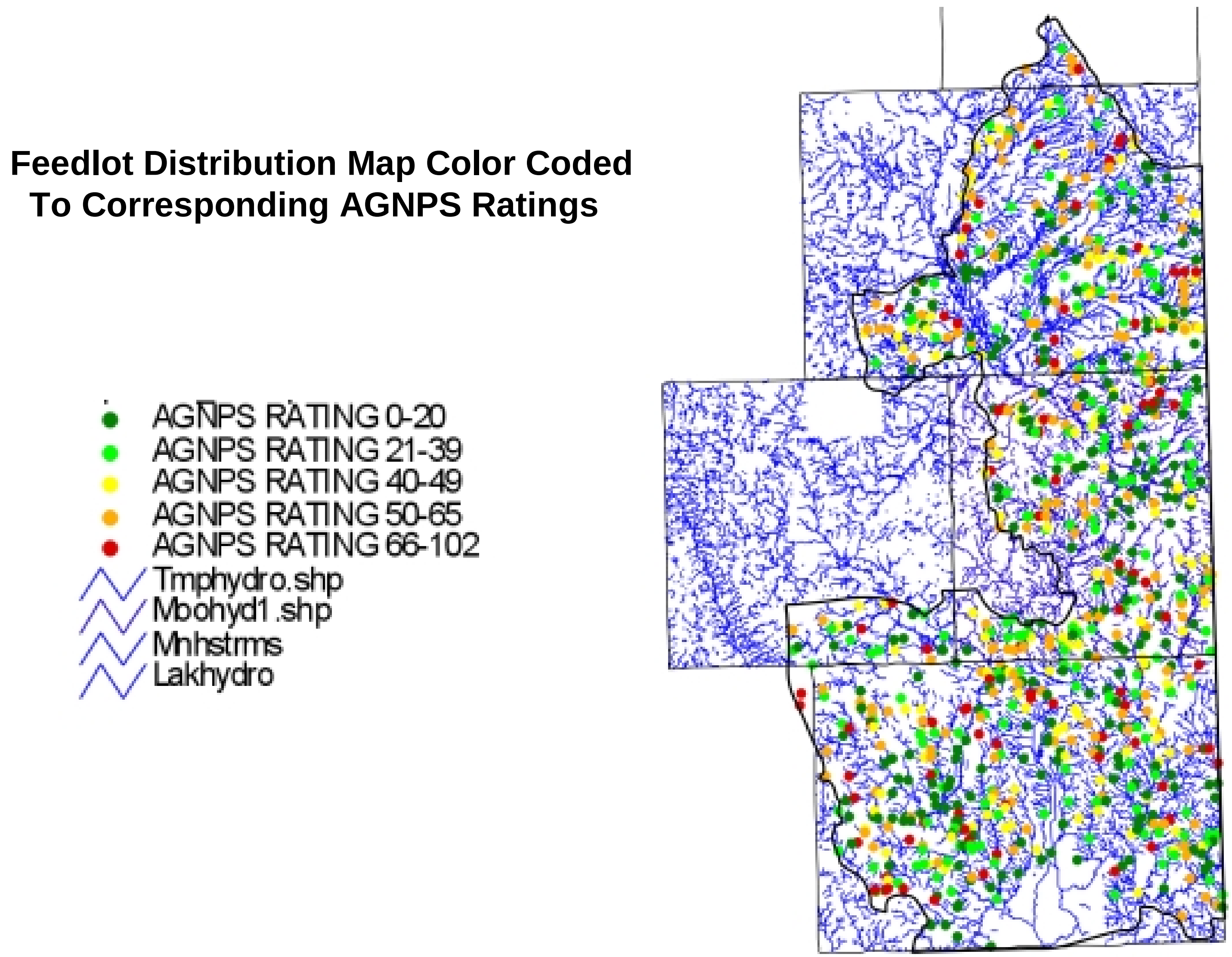


Figure 6. Feedlot Distribution Map Color Coded to Corresponding AGNPS Ratings

Appendix DD.
Mean, Min, Max, Median, Percent Violation, and Use Support by Parameter

Water Temperature C^o

Site	Stream	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	15.7	1.2	28.3	14.4	0	0	Full
T02	N. Deer Ck	10	15.0	2.8	27.5	14.6	0	0	Full
T03	Six Mile Ck	16	16.2	1.2	27.7	15.5	0	0	Full
T04	Six Mile Ck	19	16.1	1.4	29.5	15.2	0	0	Full
T05	Six Mile Ck	17	17.0	2.5	27.6	15.7	0	0	Full
T06	Deer Ck	14	17.2	1.7	29.5	16.9	0	0	Full
T07	Medary Ck	17	16.5	3.4	26.4	16.6	----	----	----
T08	Medary Ck	18	17.3	2.6	28.4	16.8	----	----	----
T09	Medary Ck	18	16.4	0.3	29.9	15.4	0	0	Full
T10	Lk Campbell Outlet	9	14.8	3.0	27.0	14.9	----	----	----
T11	Spring Ck	15	16.4	3.4	25.8	17.8	0	0	Full
T12	Flandreau Ck	15	16.5	3.9	28.0	16.6	0	0	Full
T13	Jack Moore Ck	14	17.0	1.7	28.7	17.2	0	0	Full
T14	Bachelor Ck	9	19.2	10.2	27.0	19.6	0	0	Full
T15	N. Buffalo Ck	16	16.3	1.5	31.7	17.4	----	----	----
T16	Buffalo Ck	12	16.6	1.0	31.4	16.9	----	----	----
T17	Brant Lk Outlet	15	16.4	0.1	34.8	15.8	1	7	Full
T18	Skunk Ck	16	16.5	1.5	30.2	15.9	0	0	Full
T19	Colton Ck	16	17.3	3.1	32.0	16.9	----	----	----
T20	W. Branch Skunk Ck	16	18.0	2.9	31.5	18.8	----	----	----
T21	Skunk Ck	18	18.2	0.1	32.0	19.0	0	0	Full
T22	Willow Ck	17	19.2	5.2	32.0	19.5	----	----	----
T23	Skunk Ck	18	18.7	0.4	31.0	20.3	0	0	Full
T24	Silver Ck	11	14.7	2.4	27.0	14.9	0	0	Full
T25	Slip-Up Ck	17	14.6	0.1	25.8	17.3	----	----	----
T26	W. Pipestone Ck	14	15.1	1.9	26.1	17.3	----	----	----
T27	W. Pipestone Ck	17	14.4	0.1	25.6	17.2	----	----	----
T28	Pipestone Ck	16	15.1	0.4	25.2	16.3	0	0	Full
T29	Pipestone Ck	16	15.1	0.7	26.1	16.2	0	0	Full
T30	Split Rock Ck	16	15.8	1.9	26.0	17.3	0	0	Full
T31	Split Rock Ck	16	16.5	1.9	27.8	18.3	0	0	Full
T32	Beaver Ck	17	16.0	1.3	31.3	17.7	0	0	Full
T33	Beaver Ck	17	16.6	0.1	32.0	18.3	0	0	Full
R01	BSR nr Brookings	24	17.4	4.6	27.6	17.6	0	0	Full
R02	BSR at Sinai Rd	15	15.1	2.4	29.3	13.1	0	0	Full
R03	BSR at Hwy 77	15	19.7	5.6	27.3	22.2	0	0	Full
R04	BSR at USGS Brookings	15	15.3	1.4	29.7	13.8	0	0	Full
R05	BSR nr Flandreau	13	16.1	3.2	27.4	14.8	0	0	Full
R06	BSR at Egan	14	17.0	2.1	29.2	16.6	0	0	Full
R07	BSR at Trent	15	17.3	2.9	28.7	16.9	0	0	Full
R08	BSR at USGS Dell Rapids	15	16.7	0.4	27.6	16.4	0	0	Full
R09	BSR at Hwy 38A	15	16.5	0.4	27.2	16.5	0	0	Full
R10	BSR at Western Ave	16	17.8	5.6	28.9	18.3	0	0	Full
R11	BSR at USGS N. Cliff Ave	15	17.8	3.2	27.6	16.8	0	0	Full
R12	BSR at Brandon	15	17.4	2.0	28.3	17.0	0	0	Full
R13	BSR nr Gitchie Manitou	16	17.2	2.7	26.6	17.9	0	0	Full

NOTE: 32.2 C is standard to those sites with beneficial use (5) and (6)

---- denotes no standard or beneficial use assigned

Air Temperature C°

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	17.5	-2.0	31.0	17.0	----	----	----
T02	N. Deer Ck	10	15.7	-2.0	28.0	17.5	----	----	----
T03	Six Mile Ck	16	18.5	0.1	33.0	17.5	----	----	----
T04	Six Mile Ck	19	18.3	0.1	31.0	17.0	----	----	----
T05	Six Mile Ck	17	18.4	-2.0	31.0	17.0	----	----	----
T06	Deer Ck	14	22.5	6.0	35.0	25.0	----	----	----
T07	Medary Ck	17	20.6	4.0	34.0	20.0	----	----	----
T08	Medary Ck	18	21.5	6.0	34.0	21.5	----	----	----
T09	Medary Ck	17	20.4	-6.0	34.5	21.0	----	----	----
T10	Lk Campbell Outlet	9	17.1	-5.0	30.0	16.0	----	----	----
T11	Spring Ck	15	20.1	1.0	35.0	22.0	----	----	----
T12	Flandreau Ck	15	20.3	1.0	34.0	20.0	----	----	----
T13	Jack Moore Ck	14	19.4	-2.0	32.5	21.5	----	----	----
T14	Bachelor Ck	9	23.4	12.0	35.0	24.0	----	----	----
T15	N. Buffalo Ck	16	18.8	6.0	34.0	19.0	----	----	----
T16	Buffalo Ck	12	19.2	6.0	34.0	19.5	----	----	----
T17	Brant Lk Outlet	13	18.0	4.0	32.0	18.0	----	----	----
T18	Skunk Ck	16	20.7	5.0	34.0	20.8	----	----	----
T19	Colton Ck	16	21.6	7.0	34.0	22.0	----	----	----
T20	W. Branch Skunk Ck	16	22.1	8.0	34.0	22.3	----	----	----
T21	Skunk Ck	18	22.2	7.0	34.0	22.0	----	----	----
T22	Willow Ck	16	23.8	10.0	34.0	23.8	----	----	----
T23	Skunk Ck	17	22.8	9.0	35.0	23.0	----	----	----
T24	Silver Ck	11	19.4	5.0	37.0	19.0	----	----	----
T25	Slip-Up Ck	17	19.8	5.0	39.0	20.0	----	----	----
T26	W. Pipestone Ck	14	17.6	5.0	30.0	19.3	----	----	----
T27	W. Pipestone Ck	17	18.3	5.0	33.0	19.0	----	----	----
T28	Pipestone Ck	16	15.9	5.0	27.0	16.0	----	----	----
T29	Pipestone Ck	16	17.0	5.0	30.0	18.0	----	----	----
T30	Split Rock Ck	16	17.7	5.0	31.0	18.8	----	----	----
T31	Split Rock Ck	16	20.6	6.0	35.0	20.0	----	----	----
T32	Beaver Ck	17	21.0	6.0	36.0	21.5	----	----	----
T33	Beaver Ck	17	22.4	8.0	40.0	20.5	----	----	----
R01	BSR nr Brookings	24	19.0	4.0	31.5	19.0	----	----	----
R02	BSR at Sinai Rd	15	17.3	-2.0	31.0	18.0	----	----	----
R03	BSR at Hwy 77	16	19.8	5.0	31.0	19.5	----	----	----
R04	BSR at USGS Brookings	15	18.3	5.0	33.0	19.0	----	----	----
R05	BSR nr Flandreau	13	19.8	1.0	33.5	21.0	----	----	----
R06	BSR at Egan	14	19.0	-2.0	35.0	18.5	----	----	----
R07	BSR at Trent	14	21.9	3.0	35.0	22.0	----	----	----
R08	BSR at USGS Dell Rapids	15	18.3	5.0	34.0	19.0	----	----	----
R09	BSR at Hwy 38A	15	18.9	7.0	34.0	19.5	----	----	----
R10	BSR at Western Ave	16	21.7	8.0	34.0	22.5	----	----	----
R11	BSR at USGS N. Cliff Ave	15	20.6	8.0	34.0	21.0	----	----	----
R12	BSR at Brandon	15	20.0	8.0	34.0	20.0	----	----	----
R13	BSR nr Gitchie Manitou	16	21.5	8.0	34.0	22.3	----	----	----

---- denotes no standard or beneficial use assigned

		Conductivity µS/cm							
Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	667	498	923	618	----	----	----
T02	N. Deer Ck	10	600	383	816	582	----	----	----
T03	Six Mile Ck	16	616	345	866	640	----	----	----
T04	Six Mile Ck	19	656	328	873	664	----	----	----
T05	Six Mile Ck	17	522	191	860	485	----	----	----
T06	Deer Ck	14	737	511	966	764	----	----	----
T07	Medary Ck	17	481	325	699	471	----	----	----
T08	Medary Ck	18	553	105	774	578	----	----	----
T09	Medary Ck	18	599	293	787	598	----	----	----
T10	Lk Campbell Outlet	9	1356	827	1790	1507	----	----	----
T11	Spring Ck	15	523	243	745	550	----	----	----
T12	Flandreau Ck	15	567	276	831	562	----	----	----
T13	Jack Moore Ck	14	957	565	1308	1024	----	----	----
T14	Bachelor Ck	9	978	229	1486	957	----	----	----
T15	N. Buffalo Ck	16	1048	293	1768	1070	----	----	----
T16	Buffalo Ck	12	1178	232	1827	1354	----	----	----
T17	Brant Lk Outlet	15	1260	793	1834	1219	----	----	----
T18	Skunk Ck	16	926	259	1560	884	----	----	----
T19	Colton Ck	16	820	218	1627	865	----	----	----
T20	W. Branch Skunk C	16	1055	317	1599	1129	----	----	----
T21	Skunk Ck	18	873	256	1390	921	----	----	----
T22	Willow Ck	17	628	248	1007	679	----	----	----
T23	Skunk Ck	18	960	289	2082	937	----	----	----
T24	Silver Ck	10	552	157	836	595	----	----	----
T25	Slip-Up Ck	17	496	123	878	560	----	----	----
T26	W. Pipestone Ck	14	518	81	942	567	----	----	----
T27	W. Pipestone Ck	17	435	120	811	472	----	----	----
T28	Pipestone Ck	16	682	133	1263	688	----	----	----
T29	Pipestone Ck	16	554	114	964	593	----	----	----
T30	Split Rock Ck	16	489	120	853	498	----	----	----
T31	Split Rock Ck	16	483	123	839	478	----	----	----
T32	Beaver Ck	17	502	134	885	470	----	----	----
T33	Beaver Ck	17	548	175	890	543	----	----	----
R01	BSR nr Brookings	24	826	209	1136	888	----	----	----
R02	BSR at Sinai Rd	15	791	518	1075	744	----	----	----
R03	BSR at Hwy 77	17	914	597	1220	942	----	----	----
R04	BSR at USGS Brookings	15	782	511	1068	710	----	----	----
R05	BSR nr Flandreau	13	761	500	1035	691	----	----	----
R06	BSR at Egan	14	744	518	1032	700	----	----	----
R07	BSR at Trent	15	784	546	1056	714	----	----	----
R08	BSR at USGS Dell Rapids	15	717	170	1064	799	----	----	----
R09	BSR at Hwy 38A	15	699	146	1104	737	----	----	----
R10	BSR at Western Av	16	827	335	1137	914	----	----	----
R11	BSR at USGS N. Cliff Ave	15	803	221	1264	912	----	----	----
R12	BSR at Brandon	15	821	194	1226	887	----	----	----
R13	BSR nr Gitchie Manitou	16	730	183	1098	793	----	----	----

---- denotes no standard or beneficial use assigned

Specific Conductivity µS/cm

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	8	737	667	819	751	0	0	Full
T02	N. Deer Ck	8	735	393	907	779	0	0	Full
T03	Six Mile Ck	10	732	566	860	736	0	0	Full
T04	Six Mile Ck	13	730	445	841	779	0	0	Full
T05	Six Mile Ck	12	568	238	859	611	0	0	Full
T06	Deer Ck	8	827	670	935	820	0	0	Full
T07	Medary Ck	13	544	323	651	559	0	0	Full
T08	Medary Ck	12	676	124	1607	641	0	0	Full
T09	Medary Ck	13	676	420	810	690	0	0	Full
T10	Lk Campbell Outlet	9	1447	148	1965	1570	0	0	Full
T11	Spring Ck	10	573	398	727	593	0	0	Full
T12	Flandreau Ck	11	657	330	806	696	0	0	Full
T13	Jack Moore Ck	8	1183	801	1818	1245	0	0	Full
T14	Bachelor Ck	9	1123	250	1657	1173	0	0	Full
T15	N. Buffalo Ck	15	1276	586	1932	1344	0	0	Full
T16	Buffalo Ck	11	1437	890	1840	1495	0	0	Full
T17	Brant Lk Outlet	14	1498	1051	1772	1495	0	0	Full
T18	Skunk Ck	15	1111	506	1573	1019	0	0	Full
T19	Colton Ck	16	885	369	1300	996	0	0	Full
T20	W. Branch Skunk Ck	16	1178	532	1672	1277	0	0	Full
T21	Skunk Ck	17	1010	462	1391	1023	0	0	Full
T22	Willow Ck	17	690	389	886	739	0	0	Full
T23	Skunk Ck	17	1001	466	1357	1034	0	0	Full
T24	Silver Ck	10	649	258	850	712	0	0	Full
T25	Slip-Up Ck	16	612	211	878	756	0	0	Full
T26	W. Pipestone Ck	13	644	145	1001	723	0	0	Full
T27	W. Pipestone Ck	16	542	210	808	601	0	0	Full
T28	Pipestone Ck	14	907	627	1850	755	0	0	Full
T29	Pipestone Ck	14	727	527	1034	707	0	0	Full
T30	Split Rock Ck	15	600	255	860	615	0	0	Full
T31	Split Rock Ck	15	581	224	897	586	0	0	Full
T32	Beaver Ck	15	628	215	877	673	0	0	Full
T33	Beaver Ck	15	667	207	865	730	0	0	Full
R01	BSR nr Brookings	11	870	341	1175	897	0	0	Full
R02	BSR at Sinai Rd	11	903	680	1070	899	0	0	Full
R03	BSR at Hwy 77	5	876	680	1081	870	0	0	Full
R04	BSR at USGS Brookings	10	881	699	1054	892	0	0	Full
R05	BSR nr Flandreau	9	830	643	1019	825	0	0	Full
R06	BSR at Egan	10	792	574	1015	792	0	0	Full
R07	BSR at Trent	11	846	715	1014	806	0	0	Full
R08	BSR at USGS Dell Rapids	14	864	440	1080	880	0	0	Full
R09	BSR at Hwy 38A	14	840	420	1090	838	0	0	Full
R10	BSR at Western Ave	16	946	463	1217	1080	0	0	Full
R11	BSR at USGS N. Cliff Ave	15	909	381	1512	894	0	0	Full
R12	BSR at Brandon	14	979	506	1489	1054	0	0	Full
R13	BSR nr Gitchie Manitou	16	839	318	1264	957	0	0	Full

NOTE: For beneficial uses of (9) and (10) the more strict standard of 4375 umhos/cm is applied

Salinity ppt

Site	Name	# of Samples	Mean	Min	Max	Median	Violations	Percent Violating	Use Support
T01	N. Deer Ck	13	0.4	0.3	0.5	0.4	----	----	----
T02	N. Deer Ck	10	0.4	0.2	0.4	0.4	----	----	----
T03	Six Mile Ck	16	0.3	0.3	0.4	0.3	----	----	----
T04	Six Mile Ck	19	0.4	0.2	0.4	0.4	----	----	----
T05	Six Mile Ck	17	0.3	0.1	0.4	0.3	----	----	----
T06	Deer Ck	14	0.4	0.3	0.5	0.4	----	----	----
T07	Medary Ck	17	0.3	0.2	0.3	0.3	----	----	----
T08	Medary Ck	18	0.3	0.1	0.4	0.3	----	----	----
T09	Medary Ck	18	0.3	0.2	0.4	0.4	----	----	----
T10	Lk Campbell Outlet	9	0.7	0.0	1.0	0.7	----	----	----
T11	Spring Ck	15	0.3	0.2	0.4	0.3	----	----	----
T12	Flandreau Ck	15	0.3	0.2	0.4	0.4	----	----	----
T13	Jack Moore Ck	14	0.5	0.4	0.7	0.5	----	----	----
T14	Bachelor Ck	9	0.6	0.1	0.8	0.6	----	----	----
T15	N. Buffalo Ck	16	0.6	0.0	1.0	0.7	----	----	----
T16	Buffalo Ck	12	0.7	0.2	0.9	0.7	----	----	----
T17	Brant Lk Outlet	15	0.8	0.5	0.9	0.8	----	----	----
T18	Skunk Ck	16	0.6	0.2	0.8	0.5	----	----	----
T19	Colton Ck	16	0.5	0.2	0.8	0.5	----	----	----
T20	W. Branch Skunk Ck	16	0.6	0.2	0.8	0.6	----	----	----
T21	Skunk Ck	18	0.5	0.2	0.7	0.5	----	----	----
T22	Willow Ck	17	0.4	0.2	0.7	0.4	----	----	----
T23	Skunk Ck	18	0.5	0.2	0.7	0.5	----	----	----
T24	Silver Ck	10	0.3	0.1	0.4	0.3	----	----	----
T25	Slip-Up Ck	17	0.3	0.1	1.0	0.4	----	----	----
T26	W. Pipestone Ck	14	0.3	0.0	0.5	0.4	----	----	----
T27	W. Pipestone Ck	17	0.3	0.1	0.4	0.3	----	----	----
T28	Pipestone Ck	16	0.4	0.1	0.9	0.4	----	----	----
T29	Pipestone Ck	16	0.3	0.1	0.5	0.3	----	----	----
T30	Split Rock Ck	16	0.3	0.1	0.4	0.3	----	----	----
T31	Split Rock Ck	16	0.3	0.1	0.4	0.3	----	----	----
T32	Beaver Ck	17	0.3	0.1	0.4	0.3	----	----	----
T33	Beaver Ck	17	0.3	0.1	0.4	0.3	----	----	----
R01	BSR nr Brookings	12	0.4	0.2	0.6	0.5	----	----	----
R02	BSR at Sinai Rd	15	0.4	0.3	0.5	0.5	----	----	----
R03	BSR at Hwy 77	5	0.4	0.3	0.5	0.4	----	----	----
R04	BSR at USGS Brookings	15	0.4	0.3	0.5	0.5	----	----	----
R05	BSR nr Flandreau	13	0.4	0.3	0.5	0.4	----	----	----
R06	BSR at Egan	14	0.4	0.3	0.5	0.4	----	----	----
R07	BSR at Trent	15	0.4	0.4	0.5	0.4	----	----	----
R08	BSR at USGS Dell Rapids	15	0.4	0.1	0.5	0.4	----	----	----
R09	BSR at Hwy 38A	15	0.4	0.1	0.5	0.4	----	----	----
R10	BSR at Western Ave	16	0.5	0.2	0.6	0.5	----	----	----
R11	BSR at USGS N. Cliff Ave	15	0.4	0.2	0.8	0.4	----	----	----
R12	BSR at Brandon	15	0.5	0.2	0.8	0.5	----	----	----
R13	BSR nr Gitchie Manitou	16	0.4	0.1	0.6	0.5	----	----	----

---- denotes no standard or beneficial use assigned

		Dissolved Oxygen mg/L							
Site	Name	# of Sample	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	7.7	3.4	15.3	7.3	2	15	Full
T02	N. Deer Ck	10	9.2	4.2	16.5	8.5	1	10	Full
T03	Six Mile Ck	15	8.0	4.0	14.9	7.3	1	7	Full
T04	Six Mile Ck	18	8.4	4.8	16.0	7.5	1	6	Full
T05	Six Mile Ck	17	7.4	4.7	14.0	6.7	2	12	Full
T06	Deer Ck	14	8.4	5.7	12.4	8.1	0	0	Full
T07	Medary Ck	16	9.5	6.2	14.3	8.8	----	----	----
T08	Medary Ck	17	9.9	5.4	14.0	9.4	----	----	----
T09	Medary Ck	17	9.6	5.4	15.0	9.0	0	0	Full
T10	Lk Campbell Outlet	8	8.8	2.9	20.0	7.1	----**	----	----
T11	Spring Ck	14	8.9	5.1	14.0	8.1	0	0	Full
T12	Flandreau Ck	15	8.3	2.6	14.2	8.1	1	7	Full
T13	Jack Moore Ck	13	8.3	5.3	13.8	7.2	0	0	Full
T14	Bachelor Ck	8	9.8	7.1	13.2	9.4	0	0	Full
T15	N. Buffalo Ck	15	8.4	4.5	13.5	8.6	----**	----	----
T16	Buffalo Ck	11	7.5	3.8	10.7	8.8	----**	----	----
T17	Brant Lk Outlet	13	8.9	4.2	14.3	9.5	1	8	Full
T18	Skunk Ck	15	9.7	6.8	15.3	9.7	0	0	Full
T19	Colton Ck	15	8.8	4.0	16.9	7.4	----**	----	----
T20	W. Branch Skunk Ck	15	10.1	4.2	16.0	10.2	----**	----	----
T21	Skunk Ck	17	10.7	7.3	17.3	10.8	0	0	Full
T22	Willow Ck	16	8.5	4.1	18.3	7.5	----**	----	----
T23	Skunk Ck	17	10.2	5.9	16.0	10.0	0	0	Full
T24	Silver Ck	11	6.4	3.5	8.6	6.7	----**	----**	----**
T25	Slip-Up Ck	17	9.4	3.1	17.5	9.3	----**	----	----
T26	W. Pipestone Ck	14	6.1	2.6	9.5	6.3	----**	----	----
T27	W. Pipestone Ck	16	9.5	2.5	14.6	10.0	----	----	----
T28	Pipestone Ck	16	7.9	5.1	14.4	7.1	0	0	Full
T29	Pipestone Ck	15	8.8	5.4	15.4	8.0	0	0	Full
T30	Split Rock Ck	15	8.3	3.5	16.7	7.6	1	7	Full
T31	Split Rock Ck	15	8.3	3.5	14.1	8.5	2	13	Full
T32	Beaver Ck	16	9.3	3.8	16.8	9.5	2	13	Full
T33	Beaver Ck	17	9.3	1.9	14.5	9.4	1	6	Full
R01	BSR nr Brookings	23	9.5	5.1	15.8	9.4	0	0	Full
R02	BSR at Sinai Rd	15	8.0	5.6	14.9	7.5	0	0	Full
R03	BSR at Hwy 77	16	9.9	5.1	16.6	9.6	0	0	Full
R04	BSR at USGS Brookings	15	9.0	5.1	13.3	8.7	0	0	Full
R05	BSR nr Flandreau	13	9.0	5.8	14.9	7.4	0	0	Full
R06	BSR at Egan	14	9.2	6.7	13.1	8.6	0	0	Full
R07	BSR at Trent	15	9.6	6.7	13.5	9.2	0	0	Full
R08	BSR at USGS Dell Rapids	15	8.4	4.4	12.5	7.8	1	6	Full
R09	BSR at Hwy 38A	15	8.1	4.2	11.8	8.1	2	13	Full
R10	BSR at Western Ave	16	9.5	3.1	16.3	9.8	2	13	Full
R11	BSR at USGS N. Cliff Ave	15	9.6	2.8	16.5	9.1	2	13	Full
R12	BSR at Brandon	15	9.7	4.3	15.4	9.9	1	7	Full
R13	BSR nr Gitchie Manitou	16	8.3	2.8	13.7	7.9	1	7	Full

DO standard is $\geq$ 5.0 mg/L

----** denotes no standard or beneficial use assigned for DO, but there are violations if standard were applic

---- denotes no standard or beneficial use assigned

pH units

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	8.2	7.8	8.6	8.2	0	0	Full
T02	N. Deer Ck	10	8.3	8.1	8.7	8.2	0	0	Full
T03	Six Mile Ck	16	8.2	6.9	8.7	8.3	0	0	Full
T04	Six Mile Ck	19	8.0	7.0	8.6	8.1	0	0	Full
T05	Six Mile Ck	17	8.2	7.2	8.7	8.2	0	0	Full
T06	Deer Ck	14	8.2	7.1	8.7	8.3	0	0	Full
T07	Medary Ck	17	8.2	7.5	8.7	8.3	0	0	Full
T08	Medary Ck	18	8.3	7.3	8.7	8.3	0	0	Full
T09	Medary Ck	17	8.2	7.9	8.5	8.2	0	0	Full
T10	Lk Campbell Outlet	9	7.9	7.6	8.2	8.0	0	0	Full
T11	Spring Ck	15	8.2	7.5	8.7	8.2	0	0	Full
T12	Flandreau Ck	15	8.2	7.2	8.7	8.3	0	0	Full
T13	Jack Moore Ck	14	8.1	7.6	8.6	8.1	0	0	Full
T14	Bachelor Ck	8	8.0	7.4	8.4	8.1	0	0	Full
T15	N. Buffalo Ck	16	8.0	7.6	8.5	8.0	0	0	Full
T16	Buffalo Ck	12	8.4	7.8	10.9	8.1	1	8	Full
T17	Brant Lk Outlet	14	8.2	7.8	9.0	8.2	0	0	Full
T18	Skunk Ck	16	8.0	7.7	8.4	7.9	0	0	Full
T19	Colton Ck	16	8.1	7.6	8.5	8.1	0	0	Full
T20	W. Branch Skunk Ck	16	8.1	7.1	9.1	8.1	1	6	Full
T21	Skunk Ck	18	8.2	7.0	9.5	8.2	0	0	Full
T22	Willow Ck	17	7.9	6.9	8.3	8.0	0	0	Full
T23	Skunk Ck	18	8.0	7.5	8.8	8.0	0	0	Full
T24	Silver Ck	10	7.9	7.6	8.6	7.8	0	0	Full
T25	Slip-Up Ck	16	8.1	7.4	8.6	8.1	0	0	Full
T26	W. Pipestone Ck	13	7.8	7.3	8.2	7.8	0	0	Full
T27	W. Pipestone Ck	16	8.2	7.5	8.7	8.1	0	0	Full
T28	Pipestone Ck	16	8.2	7.4	8.8	8.2	0	0	Full
T29	Pipestone Ck	16	8.2	7.4	8.6	8.2	0	0	Full
T30	Split Rock Ck	16	8.0	7.0	8.5	8.2	0	0	Full
T31	Split Rock Ck	15	8.3	7.7	9.1	8.3	0	0	Full
T32	Beaver Ck	16	8.0	7.3	8.5	8.1	0	0	Full
T33	Beaver Ck	17	8.1	7.6	8.5	8.3	0	0	Full
R01	BSR nr Brookings	24	8.2	7.0	9.0	8.2	0	0	Full
R02	BSR at Sinai Rd	15	8.3	8.0	8.7	8.4	0	0	Full
R03	BSR at Hwy 77	17	8.1	6.9	8.9	8.1	0	0	Full
R04	BSR at USGS Brookings	15	8.3	7.2	8.7	8.3	0	0	Full
R05	BSR nr Flandreau	13	8.4	7.9	8.9	8.4	0	0	Full
R06	BSR at Egan	14	8.4	7.4	8.9	8.4	0	0	Full
R07	BSR at Trent	15	8.5	7.8	9.0	8.5	0	0	Full
R08	BSR at USGS Dell Rapids	15	8.2	7.3	8.8	8.1	0	0	Full
R09	BSR at Hwy 38A	15	8.1	7.4	8.7	8.2	0	0	Full
R10	BSR at Western Ave	16	8.1	7.5	8.6	8.2	0	0	Full
R11	BSR at USGS N. Cliff Ave	15	8.2	7.8	8.9	8.1	0	0	Full
R12	BSR at Brandon	15	8.2	7.7	8.6	8.3	0	0	Full
R13	BSR nr Gitchie Manitou	16	8.2	7.2	8.6	8.2	0	0	Full

Most restrictive standard is 6.5-9.0 for River sites with beneficial use 1,5, and 9
Most restrictive standard is 6.0-9.0 for trib sites that have a beneficial use of 6 and 9
Standard of 6.0-9.5 for trib sites with beneficial use of only 9
Standard of 6.5-9.0 for trib sites with beneficial use of 5

NTU - Turbidity

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	14.4	2.1	29.0	14.0	----	----	----
T02	N. Deer Ck	10	18.3	2.2	58.8	8.1	----	----	----
T03	Six Mile Ck	16	20.4	4.7	32.0	20.2	----	----	----
T04	Six Mile Ck	19	59.7	4.3	700.0	18.8	----	----	----
T05	Six Mile Ck	17	53.4	4.7	260.0	25.0	----	----	----
T06	Deer Ck	14	53.8	4.0	340.0	18.0	----	----	----
T07	Medary Ck	17	16.5	2.0	95.0	9.0	----	----	----
T08	Medary Ck	18	16.1	1.0	55.0	13.0	----	----	----
T09	Medary Ck	18	27.7	1.0	100.0	27.0	----	----	----
T10	Lk Campbell Outlet	9	41.9	4.7	190.0	19.0	----	----	----
T11	Spring Ck	15	25.3	2.3	110.0	15.0	----	----	----
T12	Flandreau Ck	15	58.2	4.2	450.0	15.0	----	----	----
T13	Jack Moore Ck	14	14.6	0.4	35.0	11.5	----	----	----
T14	Bachelor Ck	9	20.1	0.1	110.0	4.4	----	----	----
T15	N. Buffalo Ck	16	37.1	4.9	129.0	19.1	----	----	----
T16	Buffalo Ck	12	45.8	11.6	98.2	41.9	----	----	----
T17	Brant Lk Outlet	14	8.7	2.3	21.2	8.1	----	----	----
T18	Skunk Ck	16	31.0	7.3	108.6	21.2	----	----	----
T19	Colton Ck	16	155.2	17.9	586.0	43.4	----	----	----
T20	W. Branch Skunk Ck	16	38.6	8.1	136.0	15.6	----	----	----
T21	Skunk Ck	18	66.6	13.6	245.0	37.7	----	----	----
T22	Willow Ck	17	68.0	6.7	469.0	31.0	----	----	----
T23	Skunk Ck	18	88.3	23.0	617.0	39.9	----	----	----
T24	Silver Ck	11	66.8	2.7	566.0	8.1	----	----	----
T25	Slip-Up Ck	17	200.9	8.4	1586.0	30.5	----	----	----
T26	W. Pipestone Ck	14	86.5	3.1	485.0	38.6	----	----	----
T27	W. Pipestone Ck	16	206.1	6.7	1912.0	22.7	----	----	----
T28	Pipestone Ck	16	51.4	11.7	222.0	29.2	----	----	----
T29	Pipestone Ck	16	48.7	8.8	187.0	25.6	----	----	----
T30	Split Rock Ck	16	145.0	5.2	1430.0	45.0	----	----	----
T31	Split Rock Ck	16	161.6	9.1	1536.0	31.3	----	----	----
T32	Beaver Ck	17	290.3	7.3	3057.0	22.0	----	----	----
T33	Beaver Ck	17	282.9	3.0	3066.0	28.6	----	----	----
R01	BSR nr Brookings	12	37.6	4.3	116.0	27.1	----	----	----
R02	BSR at Sinai Rd	15	59.5	20.0	130.0	45.0	----	----	----
R03	BSR at Hwy 77	5	73.3	27.0	113.0	66.4	----	----	----
R04	BSR at USGS Brookings	15	61.3	14.0	170.0	50.0	----	----	----
R05	BSR nr Flandreau	13	68.4	12.0	260.0	55.0	----	----	----
R06	BSR at Egan	14	60.3	11.0	120.0	47.5	----	----	----
R07	BSR at Trent	15	62.1	14.0	120.0	60.0	----	----	----
R08	BSR at USGS Dell Rapids	15	63.7	14.7	172.0	49.8	----	----	----
R09	BSR at Hwy 38A	15	85.0	23.1	337.0	54.1	----	----	----
R10	BSR at Western Ave	16	84.4	9.1	569.0	46.7	----	----	----
R11	BSR at USGS N. Cliff Ave	15	97.3	23.0	322.0	55.4	----	----	----
R12	BSR at Brandon	15	88.3	8.6	394.0	33.8	----	----	----
R13	BSR nr Gitchie Manitou	16	210.1	9.2	2043.0	52.4	----	----	----

---- denotes no standard or beneficial use assigned

Total Solids mg/L

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	585	404	887	574	----	----	----
T02	N. Deer Ck	10	539	394	631	568	----	----	----
T03	Six Mile Ck	16	534	410	702	525	----	----	----
T04	Six Mile Ck	19	586	366	776	579	----	----	----
T05	Six Mile Ck	17	460	212	761	510	----	----	----
T06	Deer Ck	14	722	511	1113	657	----	----	----
T07	Medary Ck	17	404	268	560	398	----	----	----
T08	Medary Ck	18	471	293	708	459	----	----	----
T09	Medary Ck	18	586	464	1011	562	----	----	----
T10	Lk Campbell Outlet	9	1388	1063	1810	1358	----	----	----
T11	Spring Ck	14	492	317	652	514	----	----	----
T12	Flandreau Ck	15	540	450	683	540	----	----	----
T13	Jack Moore Ck	14	900	639	1430	905	----	----	----
T14	Bachelor Ck	9	1037	456	1413	937	----	----	----
T15	N. Buffalo Ck	16	1086	357	1862	1133	----	----	----
T16	Buffalo Ck	12	1164	344	1509	1357	----	----	----
T17	Brant Lk Outlet	15	1203	942	1365	1205	----	----	----
T18	Skunk Ck	16	899	375	1411	817	----	----	----
T19	Colton Ck	16	852	303	1544	795	----	----	----
T20	W. Branch Skunk Ck	16	1007	320	1420	1094	----	----	----
T21	Skunk Ck	18	821	321	1222	837	----	----	----
T22	Willow Ck	17	514	330	696	522	----	----	----
T23	Skunk Ck	18	821	306	1428	819	----	----	----
T24	Silver Ck	11	472	209	854	490	----	----	----
T25	Slip-Up Ck	17	634	256	1142	622	----	----	----
T26	W. Pipestone Ck	14	469	100	713	534	----	----	----
T27	W. Pipestone Ck	17	538	250	1303	468	----	----	----
T28	Pipestone Ck	16	610	201	1043	579	----	----	----
T29	Pipestone Ck	16	500	201	763	517	----	----	----
T30	Split Rock Ck	16	514	198	1202	493	----	----	----
T31	Split Rock Ck	16	529	311	1277	445	----	----	----
T32	Beaver Ck	17	717	296	1770	625	----	----	----
T33	Beaver Ck	17	726	254	1502	641	----	----	----
R01	BSR nr Brookings	22	773	284	1033	794	----	----	----
R02	BSR at Sinai Rd	15	777	615	1007	763	----	----	----
R03	BSR at Hwy 77	17	865	687	1197	844	----	----	----
R04	BSR at USGS Brookings	15	776	556	1074	753	----	----	----
R05	BSR nr Flandreau	13	730	588	956	704	----	----	----
R06	BSR at Egan	14	683	540	950	650	----	----	----
R07	BSR at Trent	15	743	558	976	687	----	----	----
R08	BSR at USGS Dell Rapids	15	751	409	1301	742	----	----	----
R09	BSR at Hwy 38A	15	708	447	949	696	----	----	----
R10	BSR at Western Ave	16	840	531	1096	825	----	----	----
R11	BSR at USGS N. Cliff Ave	15	805	519	1046	817	----	----	----
R12	BSR at Brandon	15	794	500	1157	832	----	----	----
R13	BSR nr Gitchie Manitou	16	803	522	1569	784	----	----	----

---- denotes no standard or beneficial use assigned

Total Dissolved Solids mg/L									
Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	562	396	852	552	0	0	Full
T02	N. Deer Ck	10	498	260	620	536	0	0	Full
T03	Six Mile Ck	16	500	368	676	486	0	0	Full
T04	Six Mile Ck	19	526	304	668	548	0	0	Full
T05	Six Mile Ck	17	401	136	604	452	0	0	Full
T06	Deer Ck	14	647	496	1108	612	0	0	Full
T07	Medary Ck	17	382	256	532	384	0	0	Full
T08	Medary Ck	18	445	276	680	446	0	0	Full
T09	Medary Ck	18	533	408	980	493	0	0	Full
T10	Lk Campbell Outlet	9	1333	1056	1668	1296	0	0	Full
T11	Spring Ck	14	459	264	616	472	0	0	Full
T12	Flandreau Ck	15	479	236	636	500	0	0	Full
T13	Jack Moore Ck	14	874	580	1396	886	0	0	Full
T14	Bachelor Ck	9	992	408	1404	928	0	0	Full
T15	N. Buffalo Ck	16	1010	316	1752	1032	0	0	Full
T16	Buffalo Ck	12	1083	332	1484	1232	0	0	Full
T17	Brant Lk Outlet	15	1184	936	1344	1185	0	0	Full
T18	Skunk Ck	16	826	316	1284	777	0	0	Full
T19	Colton Ck	16	641	216	948	716	0	0	Full
T20	W. Branch Skunk Ck	16	938	252	1384	1014	0	0	Full
T21	Skunk Ck	18	715	252	1080	728	0	0	Full
T22	Willow Ck	17	430	284	576	436	0	0	Full
T23	Skunk Ck	18	699	220	1044	762	0	0	Full
T24	Silver Ck	11	426	172	784	464	0	0	Full
T25	Slip-Up Ck	17	402	172	628	452	0	0	Full
T26	W. Pipestone Ck	14	392	75	640	426	0	0	Full
T27	W. Pipestone Ck	17	327	124	520	344	0	0	Full
T28	Pipestone Ck	16	537	172	1028	507	0	0	Full
T29	Pipestone Ck	16	435	152	660	462	0	0	Full
T30	Split Rock Ck	16	373	112	584	372	0	0	Full
T31	Split Rock Ck	16	351	148	600	342	0	0	Full
T32	Beaver Ck	17	431	190	612	500	0	0	Full
T33	Beaver Ck	17	457	188	608	512	0	0	Full
R01	BSR nr Brookings	22	663	228	900	654	0	0	Full
R02	BSR at Sinai Rd	15	654	420	804	692	0	0	Full
R03	BSR at Hwy 77	17	723	556	1009	704	0	0	Full
R04	BSR at USGS Brookings	15	655	405	908	640	0	0	Full
R05	BSR nr Flandreau	13	611	440	844	608	0	0	Full
R06	BSR at Egan	14	578	388	808	576	0	0	Full
R07	BSR at Trent	15	621	480	824	612	0	0	Full
R08	BSR at USGS Dell Rapids	15	631	268	1252	585	0	0	Full
R09	BSR at Hwy 38A	15	557	200	828	552	0	0	Full
R10	BSR at Western Ave	16	701	364	1020	768	0	0	Full
R11	BSR at USGS N. Cliff Ave	15	642	248	1016	716	0	0	Full
R12	BSR at Brandon	15	630	216	980	644	0	0	Full
R13	BSR nr Gitchie Manitou	16	574	260	808	628	0	0	Full

Standard is 1750 mg/L for River sites and 4375 mg/L for all tributary sites for beneficial use (1) and (9)

Un-ionized Ammonia mg/L

Site	Name	# of Sample	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	0.004	0.000	0.011	0.004	0	0	Full
T02	N. Deer Ck	10	0.006	0.001	0.020	0.005	0	0	Full
T03	Six Mile Ck	16	0.007	0.001	0.022	0.006	0	0	Full
T04	Six Mile Ck	19	0.006	0.001	0.026	0.005	0	0	Full
T05	Six Mile Ck	17	0.012	0.001	0.040	0.006	0	0	Full
T06	Deer Ck	14	0.005	0.000	0.015	0.003	0	0	Full
T07	Medary Ck	17	0.005	0.001	0.012	0.005	----	----	----
T08	Medary Ck	18	0.006	0.001	0.013	0.004	----	----	----
T09	Medary Ck	18	0.005	0.000	0.012	0.004	0	0	Full
T10	Lk Campbell Outlet	9	0.050	0.005	0.211	0.023	---- **	----	----
T11	Spring Ck	14	0.004	0.000	0.010	0.004	0	0	Full
T12	Flandreau Ck	15	0.007	0.000	0.012	0.007	0	0	Full
T13	Jack Moore Ck	14	0.008	0.001	0.032	0.006	0	0	Full
T14	Bachelor Ck	9	0.006	0.000	0.017	0.006	0	0	Full
T15	N. Buffalo Ck	16	0.005	0.000	0.016	0.004	----	----	----
T16	Buffalo Ck	12	0.032	0.003	0.220	0.015	----**	----	----
T17	Brant Lk Outlet	15	0.020	0.001	0.066	0.016	0	0	Full
T18	Skunk Ck	16	0.006	0.001	0.019	0.004	0	0	Full
T19	Colton Ck	16	0.010	0.002	0.031	0.009	----	----	----
T20	W. Branch Skunk Ck	16	0.017	0.001	0.146	0.005	----**	----	----
T21	Skunk Ck	18	0.011	0.000	0.057	0.005	0	0	Full
T22	Willow Ck	17	0.008	0.001	0.018	0.005	----	----	----
T23	Skunk Ck	18	0.007	0.002	0.016	0.005	0	0	Full
T24	Silver Ck	11	0.005	0.000	0.017	0.003	0	0	Full
T25	Slip-Up Ck	17	0.006	0.000	0.013	0.006	----	----	----
T26	W. Pipestone Ck	14	0.007	0.000	0.023	0.006	----	----	----
T27	W. Pipestone Ck	17	0.008	0.000	0.028	0.005	----	----	----
T28	Pipestone Ck	16	0.015	0.003	0.055	0.007	0	0	Full
T29	Pipestone Ck	16	0.005	0.000	0.026	0.003	0	0	Full
T30	Split Rock Ck	16	0.006	0.000	0.039	0.004	0	0	Full
T31	Split Rock Ck	16	0.009	0.000	0.037	0.007	0	0	Full
T32	Beaver Ck	17	0.004	0.000	0.014	0.003	0	0	Full
T33	Beaver Ck	17	0.006	0.000	0.032	0.004	0	0	Full
R01	BSR nr Brookings	24	0.005	0.000	0.043	0.002	0	0	Full
R02	BSR at Sinai Rd	15	0.006	0.001	0.018	0.005	0	0	Full
R03	BSR at Hwy 77	17	0.003	0.000	0.021	0.001	0	0	Full
R04	BSR at USGS Brookings	15	0.004	0.001	0.012	0.004	0	0	Full
R05	BSR nr Flandreau	13	0.005	0.000	0.014	0.005	0	0	Full
R06	BSR at Egan	14	0.008	0.001	0.028	0.005	0	0	Full
R07	BSR at Trent	15	0.006	0.001	0.025	0.004	0	0	Full
R08	BSR at USGS Dell Rapids	15	0.010	0.000	0.040	0.007	0	0	Full
R09	BSR at Hwy 38A	15	0.005	0.001	0.016	0.004	0	0	Full
R10	BSR at Western Ave	16	0.006	0.000	0.021	0.004	0	0	Full
R11	BSR at USGS N. Cliff Ave	15	0.010	0.001	0.026	0.008	0	0	Full
R12	BSR at Brandon	15	0.008	0.002	0.019	0.005	0	0	Full
R13	BSR nr Gitchie Manitou	16	0.010	0.001	0.036	0.005	0	0	Full

----** denotes violations of both beneficial use 5 and 6 if standard was applicable

---- no standard or beneficial use assigned

NOTE:for beneficial use (5) the standard is< 0.07 mg/L;for beneficial use (6) the standard is<0.0875 mg/L

Nitrate-Nitrite as Nitrogen mg/L

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	0.112	0.021	0.603	0.052	0	0	Full
T02	N. Deer Ck	10	0.346	0.015	1.713	0.046	0	0	Full
T03	Six Mile Ck	16	0.321	0.027	0.935	0.304	0	0	Full
T04	Six Mile Ck	19	0.687	0.207	1.738	0.637	0	0	Full
T05	Six Mile Ck	17	0.438	0.060	1.168	0.364	0	0	Full
T06	Deer Ck	14	0.287	0.032	1.228	0.221	0	0	Full
T07	Medary Ck	17	3.041	1.427	6.331	2.673	0	0	Full
T08	Medary Ck	18	0.903	0.123	3.766	0.805	0	0	Full
T09	Medary Ck	18	0.944	0.561	2.087	0.736	0	0	Full
T10	Lk Campbell Outlet	9	2.129	0.051	18.484	0.097	0	0	Full
T11	Spring Ck	14	2.255	1.086	4.192	2.161	0	0	Full
T12	Flandreau Ck	15	0.712	0.169	1.559	0.576	0	0	Full
T13	Jack Moore Ck	14	0.325	0.025	1.164	0.165	0	0	Full
T14	Bachelor Ck	9	1.099	0.576	2.277	0.810	0	0	Full
T15	N. Buffalo Ck	16	0.539	0.048	1.734	0.319	0	0	Full
T16	Buffalo Ck	12	0.298	0.034	1.034	0.100	0	0	Full
T17	Brant Lk Outlet	15	0.664	0.068	5.844	0.296	0	0	Full
T18	Skunk Ck	16	0.437	0.062	0.990	0.277	0	0	Full
T19	Colton Ck	16	1.759	0.033	3.688	1.790	0	0	Full
T20	W. Branch Skunk Ck	16	1.214	0.066	3.056	1.059	0	0	Full
T21	Skunk Ck	18	0.647	0.039	2.269	0.381	0	0	Full
T22	Willow Ck	17	2.372	0.085	5.047	2.143	0	0	Full
T23	Skunk Ck	18	0.736	0.042	2.217	0.703	0	0	Full
T24	Silver Ck	11	0.707	0.034	1.864	0.372	0	0	Full
T25	Slip-Up Ck	17	4.230	1.804	7.209	3.557	0	0	Full
T26	W. Pipestone Ck	14	2.562	0.092	9.822	2.037	0	0	Full
T27	W. Pipestone Ck	17	2.369	0.830	5.485	2.059	0	0	Full
T28	Pipestone Ck	16	3.306	0.245	6.625	2.861	0	0	Full
T29	Pipestone Ck	16	2.648	0.122	6.368	2.100	0	0	Full
T30	Split Rock Ck	16	2.535	0.051	5.691	2.178	0	0	Full
T31	Split Rock Ck	16	2.493	0.264	5.153	2.338	0	0	Full
T32	Beaver Ck	17	4.390	1.106	8.166	4.396	0	0	Full
T33	Beaver Ck	17	4.208	1.180	7.378	4.731	0	0	Full
R01	BSR nr Brookings	23	0.316	0.039	1.470	0.100	0	0	Full
R02	BSR at Sinai Rd	15	0.178	0.007	0.789	0.088	0	0	Full
R03	BSR at Hwy 77	17	0.660	0.020	2.500	0.275	0	0	Full
R04	BSR at USGS Brookings	15	0.692	0.008	1.299	0.653	0	0	Full
R05	BSR nr Flandreau	13	0.371	0.036	1.297	0.281	0	0	Full
R06	BSR at Egan	14	0.318	0.038	0.957	0.278	0	0	Full
R07	BSR at Trent	15	0.282	0.032	1.278	0.078	0	0	Full
R08	BSR at USGS Dell Rapids	15	0.650	0.032	1.683	0.472	0	0	Full
R09	BSR at Hwy 38A	15	0.773	0.036	3.642	0.462	0	0	Full
R10	BSR at Western Ave	16	0.760	0.039	3.294	0.501	0	0	Full
R11	BSR at USGS N. Cliff Ave	15	3.295	0.628	10.086	2.017	1	7	Full
R12	BSR at Brandon	15	3.450	0.689	14.968	1.824	1	7	Full
R13	BSR nr Gitchie Manitou	16	2.853	1.451	9.765	2.063	0	0	Full

Most restrictive standard is 10 for River sites with beneficial use (1) and (9)

All tributary sites have a standard of 88 for beneficial use (9)

Ammonia mg/L

Site	Name	# of Sample	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	0.092	0.015	0.207	0.094	----	----	----
T02	N. Deer Ck	10	0.111	0.022	0.306	0.087	----	----	----
T03	Six Mile Ck	16	0.156	0.015	0.486	0.107	----	----	----
T04	Six Mile Ck	19	0.176	0.015	0.512	0.146	----	----	----
T05	Six Mile Ck	17	0.251	0.018	1.002	0.215	----	----	----
T06	Deer Ck	14	0.093	0.016	0.195	0.061	----	----	----
T07	Medary Ck	17	0.102	0.023	0.188	0.105	----	----	----
T08	Medary Ck	18	0.102	0.030	0.245	0.087	----	----	----
T09	Medary Ck	18	0.100	0.011	0.221	0.107	----	----	----
T10	Lk Campbell Outlet	9	2.121	0.068	5.948	1.672	----	----	----
T11	Spring Ck	14	0.115	0.001	0.237	0.115	----	----	----
T12	Flandreau Ck	15	0.140	0.005	0.323	0.166	----	----	----
T13	Jack Moore Ck	14	0.132	0.031	0.318	0.113	----	----	----
T14	Bachelor Ck	9	0.189	0.057	0.433	0.140	----	----	----
T15	N. Buffalo Ck	16	0.176	0.042	0.558	0.133	----	----	----
T16	Buffalo Ck	12	0.456	0.121	2.144	0.259	----	----	----
T17	Brant Lk Outlet	15	0.366	0.041	0.874	0.242	----	----	----
T18	Skunk Ck	16	0.216	0.045	0.879	0.170	----	----	----
T19	Colton Ck	16	0.263	0.026	0.542	0.283	----	----	----
T20	W. Branch Skunk Ck	16	0.290	0.023	0.840	0.174	----	----	----
T21	Skunk Ck	18	0.302	0.000	2.295	0.113	----	----	----
T22	Willow Ck	17	0.272	0.022	0.668	0.246	----	----	----
T23	Skunk Ck	18	0.291	0.037	1.702	0.142	----	----	----
T24	Silver Ck	11	0.238	0.082	0.761	0.126	----	----	----
T25	Slip-Up Ck	17	0.344	0.052	1.790	0.184	----	----	----
T26	W. Pipestone Ck	14	0.355	0.054	0.937	0.346	----	----	----
T27	W. Pipestone Ck	17	0.308	0.015	1.436	0.121	----	----	----
T28	Pipestone Ck	16	0.347	0.059	1.604	0.183	----	----	----
T29	Pipestone Ck	16	0.162	0.005	0.972	0.068	----	----	----
T30	Split Rock Ck	16	0.204	0.022	0.899	0.091	----	----	----
T31	Split Rock Ck	16	0.230	0.029	0.966	0.106	----	----	----
T32	Beaver Ck	17	0.377	0.022	2.605	0.061	----	----	----
T33	Beaver Ck	17	0.324	0.005	1.865	0.058	----	----	----
R01	BSR nr Brookings	23	0.094	0.019	0.585	0.024	----	----	----
R02	BSR at Sinai Rd	15	0.090	0.016	0.235	0.082	----	----	----
R03	BSR at Hwy 77	17	0.045	0.019	0.133	0.019	----	----	----
R04	BSR at USGS Brook	15	0.085	0.030	0.196	0.075	----	----	----
R05	BSR nr Flandreau	13	0.086	0.005	0.288	0.059	----	----	----
R06	BSR at Egan	14	0.113	0.007	0.336	0.106	----	----	----
R07	BSR at Trent	15	0.073	0.011	0.195	0.063	----	----	----
R08	BSR at USGS Dell Rapids	15	0.188	0.038	0.960	0.115	----	----	----
R09	BSR at Hwy 38A	15	0.186	0.015	1.001	0.091	----	----	----
R10	BSR at Western Ave	16	0.167	0.015	0.643	0.085	----	----	----
R11	BSR at USGS N. Cliff Ave	15	0.216	0.019	0.924	0.140	----	----	----
R12	BSR at Brandon	15	0.196	0.023	0.922	0.109	----	----	----
R13	BSR nr Gitchie Manitou	16	0.221	0.039	0.864	0.099	----	----	----

---- denotes no standard or beneficial use assigned

Organic Nitrogen mg/L

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	1.035	0.419	1.525	0.976	----	----	----
T02	N. Deer Ck	10	1.051	0.560	1.648	0.864	----	----	----
T03	Six Mile Ck	16	1.445	0.794	2.260	1.461	----	----	----
T04	Six Mile Ck	19	1.194	0.586	3.870	0.954	----	----	----
T05	Six Mile Ck	17	1.096	0.605	1.736	0.968	----	----	----
T06	Deer Ck	14	0.975	0.444	2.273	0.800	----	----	----
T07	Medary Ck	17	1.104	0.580	1.818	1.014	----	----	----
T08	Medary Ck	18	1.073	0.364	1.794	1.040	----	----	----
T09	Medary Ck	18	0.954	0.487	1.683	0.906	----	----	----
T10	Lk Campbell Outlet	9	3.322	0.694	10.721	1.506	----	----	----
T11	Spring Ck	14	1.116	0.536	2.207	0.955	----	----	----
T12	Flandreau Ck	15	1.063	0.451	2.422	0.771	----	----	----
T13	Jack Moore Ck	14	1.510	1.035	2.186	1.430	----	----	----
T14	Bachelor Ck	9	1.295	0.456	2.728	1.309	----	----	----
T15	N. Buffalo Ck	16	1.390	0.466	2.223	1.374	----	----	----
T16	Buffalo Ck	12	2.573	1.090	5.018	2.572	----	----	----
T17	Brant Lk Outlet	15	1.407	0.666	2.616	1.547	----	----	----
T18	Skunk Ck	16	1.574	0.426	3.448	1.462	----	----	----
T19	Colton Ck	16	2.218	0.736	4.203	1.630	----	----	----
T20	W. Branch Skunk Ck	16	1.632	0.538	4.508	1.331	----	----	----
T21	Skunk Ck	18	1.800	0.744	2.940	1.815	----	----	----
T22	Willow Ck	17	1.568	0.544	3.270	1.557	----	----	----
T23	Skunk Ck	18	1.900	0.808	4.252	1.898	----	----	----
T24	Silver Ck	11	1.420	0.694	2.960	1.386	----	----	----
T25	Slip-Up Ck	17	2.423	1.221	5.610	2.103	----	----	----
T26	W. Pipestone Ck	14	1.958	1.044	3.085	1.765	----	----	----
T27	W. Pipestone Ck	17	2.375	0.848	7.286	2.169	----	----	----
T28	Pipestone Ck	16	1.664	0.897	2.826	1.622	----	----	----
T29	Pipestone Ck	16	1.455	0.600	2.254	1.459	----	----	----
T30	Split Rock Ck	16	2.014	0.576	6.710	1.601	----	----	----
T31	Split Rock Ck	16	2.144	1.100	6.400	1.721	----	----	----
T32	Beaver Ck	17	2.551	0.625	10.388	1.525	----	----	----
T33	Beaver Ck	17	2.254	0.500	9.014	1.432	----	----	----
R01	BSR nr Brookings	12	1.715	0.945	3.350	1.549	----	----	----
R02	BSR at Sinai Rd	15	2.031	1.278	2.925	2.105	----	----	----
R03	BSR at Hwy 77	5	2.295	1.805	3.001	2.158	----	----	----
R04	BSR at USGS Brookings	15	2.070	1.302	3.392	1.981	----	----	----
R05	BSR nr Flandreau	13	2.129	1.104	2.708	2.352	----	----	----
R06	BSR at Egan	14	2.004	1.272	2.460	2.054	----	----	----
R07	BSR at Trent	15	2.110	1.632	2.577	2.158	----	----	----
R08	BSR at USGS Dell Rapids	15	1.871	1.100	2.602	1.945	----	----	----
R09	BSR at Hwy 38A	15	1.766	0.999	2.991	1.776	----	----	----
R10	BSR at Western Ave	16	1.667	0.700	2.654	1.736	----	----	----
R11	BSR at USGS N. Cliff Ave	15	2.064	1.192	2.906	2.154	----	----	----
R12	BSR at Brandon	15	2.064	1.249	2.774	2.100	----	----	----
R13	BSR nr Gitchie Manitou	16	2.300	1.312	6.561	2.061	----	----	----

---- no standard or beneficial use assigned

Total Kjeldahl Nitrogen mg/L

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	1.128	0.462	1.654	1.027	----	----	----
T02	N. Deer Ck	10	1.162	0.582	1.893	0.968	----	----	----
T03	Six Mile Ck	16	1.601	0.809	2.329	1.575	----	----	----
T04	Six Mile Ck	19	1.370	0.667	4.382	1.152	----	----	----
T05	Six Mile Ck	17	1.347	0.623	2.738	1.223	----	----	----
T06	Deer Ck	14	1.069	0.463	2.372	0.871	----	----	----
T07	Medary Ck	17	1.206	0.631	2.006	1.132	----	----	----
T08	Medary Ck	18	1.175	0.469	1.866	1.155	----	----	----
T09	Medary Ck	18	1.133	0.527	2.517	1.050	----	----	----
T10	Lk Campbell Outlet	9	5.443	1.480	15.718	3.238	----	----	----
T11	Spring Ck	14	0.438	0.017	1.162	0.287	----	----	----
T12	Flandreau Ck	15	1.202	0.478	2.619	0.951	----	----	----
T13	Jack Moore Ck	14	1.642	1.133	2.392	1.604	----	----	----
T14	Bachelor Ck	9	1.484	0.596	3.034	1.366	----	----	----
T15	N. Buffalo Ck	16	1.565	0.511	2.473	1.646	----	----	----
T16	Buffalo Ck	12	3.029	1.223	5.139	2.858	----	----	----
T17	Brant Lk Outlet	15	1.672	0.168	2.662	2.045	----	----	----
T18	Skunk Ck	16	1.790	0.478	3.523	1.632	----	----	----
T19	Colton Ck	16	2.481	0.816	4.485	1.966	----	----	----
T20	W. Branch Skunk (	16	1.921	0.630	4.620	1.525	----	----	----
T21	Skunk Ck	18	2.102	0.769	5.139	1.898	----	----	----
T22	Willow Ck	17	1.841	0.606	3.660	1.813	----	----	----
T23	Skunk Ck	18	2.190	0.947	4.503	2.036	----	----	----
T24	Silver Ck	11	1.658	0.791	3.136	1.606	----	----	----
T25	Slip-Up Ck	17	2.682	0.159	6.368	2.305	----	----	----
T26	W. Pipestone Ck	14	2.314	1.098	3.629	2.203	----	----	----
T27	W. Pipestone Ck	17	2.684	0.887	7.930	2.312	----	----	----
T28	Pipestone Ck	16	1.978	0.514	3.440	1.895	----	----	----
T29	Pipestone Ck	16	1.616	0.600	2.727	1.527	----	----	----
T30	Split Rock Ck	16	2.217	0.612	7.411	1.732	----	----	----
T31	Split Rock Ck	16	2.374	1.142	7.078	1.828	----	----	----
T32	Beaver Ck	17	2.928	0.656	11.040	1.586	----	----	----
T33	Beaver Ck	17	2.578	0.500	9.932	1.490	----	----	----
R01	BSR nr Brookings	24	1.744	0.930	3.445	1.589	----	----	----
R02	BSR at Sinai Rd	15	2.121	1.467	3.059	2.219	----	----	----
R03	BSR at Hwy 77	17	1.952	0.990	4.150	1.640	----	----	----
R04	BSR at USGS Brookings	15	2.155	1.347	3.584	2.041	----	----	----
R05	BSR nr Flandreau	13	2.216	1.112	2.981	2.390	----	----	----
R06	BSR at Egan	14	2.117	1.287	2.579	2.144	----	----	----
R07	BSR at Trent	15	2.183	1.687	2.630	2.221	----	----	----
R08	BSR at USGS Dell Rapids	15	2.059	1.154	3.530	2.100	----	----	----
R09	BSR at Hwy 38A	15	1.952	1.092	3.819	1.866	----	----	----
R10	BSR at Western A\	16	1.834	0.846	2.992	1.774	----	----	----
R11	BSR at USGS N. Cliff Ave	15	2.279	1.288	3.402	2.343	----	----	----
R12	BSR at Brandon	15	2.260	1.317	3.564	2.289	----	----	----
R13	BSR nr Gitchie Manitou	16	2.520	1.406	7.265	2.181	----	----	----

---- denotes no standard or beneficial use assigned

Total Phosphorus mg/L

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	0.145	0.027	0.299	0.130	----	----	----
T02	N. Deer Ck	10	0.187	0.034	0.550	0.107	----	----	----
T03	Six Mile Ck	16	0.148	0.054	0.233	0.138	----	----	----
T04	Six Mile Ck	19	0.200	0.030	1.413	0.109	----	----	----
T05	Six Mile Ck	17	0.259	0.048	0.590	0.196	----	----	----
T06	Deer Ck	14	0.169	0.020	0.699	0.075	----	----	----
T07	Medary Ck	17	0.110	0.026	0.392	0.095	----	----	----
T08	Medary Ck	18	0.138	0.022	0.535	0.105	----	----	----
T09	Medary Ck	18	0.133	0.027	0.352	0.127	----	----	----
T10	Lk Campbell Outlet	9	0.431	0.103	1.390	0.330	----	----	----
T11	Spring Ck	14	0.153	0.012	0.426	0.132	----	----	----
T12	Flandreau Ck	15	0.234	0.034	0.803	0.156	----	----	----
T13	Jack Moore Ck	14	0.266	0.105	0.553	0.213	----	----	----
T14	Bachelor Ck	9	0.237	0.067	0.796	0.088	----	----	----
T15	N. Buffalo Ck	16	0.332	0.070	0.604	0.314	----	----	----
T16	Buffalo Ck	12	0.422	0.191	0.681	0.388	----	----	----
T17	Brant Lk Outlet	15	0.177	0.036	0.351	0.165	----	----	----
T18	Skunk Ck	16	0.287	0.063	0.671	0.256	----	----	----
T19	Colton Ck	16	0.666	0.101	1.558	0.514	----	----	----
T20	W. Branch Skunk Ck	16	0.485	0.051	1.983	0.313	----	----	----
T21	Skunk Ck	18	0.566	0.099	2.554	0.318	----	----	----
T22	Willow Ck	17	0.424	0.112	1.220	0.403	----	----	----
T23	Skunk Ck	18	0.432	0.096	1.546	0.273	----	----	----
T24	Silver Ck	11	0.561	0.092	1.190	0.488	----	----	----
T25	Slip-Up Ck	17	0.663	0.044	2.289	0.355	----	----	----
T26	W. Pipestone Ck	14	0.615	0.117	1.027	0.710	----	----	----
T27	W. Pipestone Ck	17	0.678	0.075	2.563	0.320	----	----	----
T28	Pipestone Ck	16	0.444	0.148	0.983	0.347	----	----	----
T29	Pipestone Ck	16	0.360	0.090	0.814	0.277	----	----	----
T30	Split Rock Ck	16	0.623	0.099	2.669	0.326	----	----	----
T31	Split Rock Ck	16	0.571	0.073	2.542	0.290	----	----	----
T32	Beaver Ck	17	0.742	0.067	3.766	0.177	----	----	----
T33	Beaver Ck	17	0.687	0.046	3.968	0.275	----	----	----
R01	BSR nr Brookings	24	0.324	0.047	0.648	0.345	----	----	----
R02	BSR at Sinai Rd	15	0.381	0.143	0.647	0.362	----	----	----
R03	BSR at Hwy 77	17	0.502	0.233	0.785	0.507	----	----	----
R04	BSR at USGS Brookings	15	0.483	0.255	0.719	0.471	----	----	----
R05	BSR nr Flandreau	13	0.421	0.180	0.968	0.357	----	----	----
R06	BSR at Egan	14	0.342	0.216	0.522	0.335	----	----	----
R07	BSR at Trent	15	0.354	0.208	0.608	0.344	----	----	----
R08	BSR at USGS Dell Rapids	15	0.404	0.166	0.994	0.378	----	----	----
R09	BSR at Hwy 38A	15	0.465	0.140	1.201	0.346	----	----	----
R10	BSR at Western Ave	16	0.400	0.097	1.249	0.246	----	----	----
R11	BSR at USGS N. Cliff Ave	15	0.944	0.291	2.696	0.726	----	----	----
R12	BSR at Brandon	15	0.987	0.267	3.352	0.702	----	----	----
R13	BSR nr Gitchie Manitou	16	0.930	0.334	2.889	0.696	----	----	----

---- denotes no standard or beneficial use assigned

Total Dissolved Phosphorus mg/L

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	0.085	0.005	0.255	0.059	----	----	----
T02	N. Deer Ck	10	0.121	0.013	0.348	0.063	----	----	----
T03	Six Mile Ck	16	0.036	0.006	0.115	0.030	----	----	----
T04	Six Mile Ck	19	0.058	0.005	0.248	0.036	----	----	----
T05	Six Mile Ck	17	0.117	0.009	0.268	0.110	----	----	----
T06	Deer Ck	14	0.044	0.003	0.140	0.032	----	----	----
T07	Medary Ck	17	0.049	0.005	0.164	0.039	----	----	----
T08	Medary Ck	18	0.065	0.005	0.319	0.040	----	----	----
T09	Medary Ck	18	0.033	0.004	0.128	0.025	----	----	----
T10	Lk Campbell Outlet	9	0.088	0.029	0.194	0.062	----	----	----
T11	Spring Ck	14	0.147	0.012	0.426	0.118	----	----	----
T12	Flandreau Ck	15	0.112	0.017	0.246	0.089	----	----	----
T13	Jack Moore Ck	14	0.172	0.062	0.410	0.113	----	----	----
T14	Bachelor Ck	9	0.126	0.031	0.316	0.051	----	----	----
T15	N. Buffalo Ck	16	0.163	0.041	0.581	0.107	----	----	----
T16	Buffalo Ck	12	0.147	0.039	0.575	0.093	----	----	----
T17	Brant Lk Outlet	15	0.097	0.034	0.273	0.074	----	----	----
T18	Skunk Ck	16	0.113	0.009	0.475	0.076	----	----	----
T19	Colton Ck	16	0.264	0.022	0.684	0.232	----	----	----
T20	W. Branch Skunk Ck	16	0.224	0.017	0.542	0.143	----	----	----
T21	Skunk Ck	18	0.164	0.010	0.566	0.085	----	----	----
T22	Willow Ck	17	0.242	0.058	0.523	0.221	----	----	----
T23	Skunk Ck	18	0.148	0.005	0.520	0.089	----	----	----
T24	Silver Ck	11	0.410	0.176	0.710	0.360	----	----	----
T25	Slip-Up Ck	17	0.201	0.006	0.980	0.098	----	----	----
T26	W. Pipestone Ck	14	0.377	0.076	0.720	0.365	----	----	----
T27	W. Pipestone Ck	17	0.212	0.011	0.718	0.119	----	----	----
T28	Pipestone Ck	16	0.265	0.032	0.741	0.263	----	----	----
T29	Pipestone Ck	16	0.188	0.012	0.718	0.139	----	----	----
T30	Split Rock Ck	16	0.145	0.010	0.586	0.104	----	----	----
T31	Split Rock Ck	16	0.138	0.005	0.496	0.091	----	----	----
T32	Beaver Ck	17	0.198	0.023	1.103	0.075	----	----	----
T33	Beaver Ck	17	0.171	0.018	0.713	0.074	----	----	----
R01	BSR nr Brookings	24	0.118	0.010	0.498	0.040	----	----	----
R02	BSR at Sinai Rd	15	0.076	0.022	0.272	0.053	----	----	----
R03	BSR at Hwy 77	17	0.122	0.014	0.428	0.087	----	----	----
R04	BSR at USGS Brookings	15	0.122	0.019	0.291	0.115	----	----	----
R05	BSR nr Flandreau	13	0.086	0.029	0.219	0.067	----	----	----
R06	BSR at Egan	14	0.073	0.005	0.183	0.062	----	----	----
R07	BSR at Trent	15	0.074	0.024	0.259	0.047	----	----	----
R08	BSR at USGS Dell Rapids	15	0.160	0.018	0.398	0.131	----	----	----
R09	BSR at Hwy 38A	15	0.153	0.034	0.339	0.127	----	----	----
R10	BSR at Western Ave	16	0.150	0.022	0.417	0.115	----	----	----
R11	BSR at USGS N. Cliff Ave	15	0.643	0.186	2.642	0.351	----	----	----
R12	BSR at Brandon	15	0.654	0.167	3.132	0.301	----	----	----
R13	BSR nr Gitchie Manitou	16	0.460	0.185	1.938	0.306	----	----	----

---- denotes no standard or beneficial use assigned

Site	Name	# of Samples	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
					Fecal Coliform Bacteria cfu/100mL				
T01	N. Deer Ck	9	607	30	1900	500	0	0	Full
T02	N. Deer Ck	7	6310	70	39000	300	2	29	Not
T03	Six Mile Ck	11	534	10	1800	200	0	0	Full
T04	Six Mile Ck	13	7613	70	67000	1700	6	46	Not
T05	Six Mile Ck	12	6278	230	30000	1850	5	42	Not
T06	Deer Ck	11	1126	60	3300	900	1	9	Full
T07	Medary Ck	12	1426	60	4600	1150	----**	----	----
T08	Medary Ck	13	1412	80	9000	730	----**	----	----
T09	Medary Ck	12	1184	90	7200	445	2	17	Full
T10	Lk Campbell Outlet	6	1587	10	7200	305	----**	----	----
T11	Spring Ck	11	3001	270	9000	1900	5	46	Not
T12	Flandreau Ck	11	3095	270	10000	1300	4	36	Not
T13	Jack Moore Ck	9	5811	700	19000	3200	5	56	Not
T14	Bachelor Ck	8	12460	580	55000	1150	3	38	Not
T15	N. Buffalo Ck	11	3527	99	16000	2800	----**	----	----
T16	Buffalo Ck	8	606	50	2200	350	---- **	----	----
T17	Brant Lk Outlet	10	1683	80	9800	160	2	20	Full
T18	Skunk Ck	11	2909	100	9100	1100	4	36	Not
T19	Colton Ck	11	28555	300	210000	4600	---- **	----	----
T20	W. Branch Skunk (	11	19850	800	160000	2100	----**	----	----
T21	Skunk Ck	12	10605	60	106000	405	2	17	Full
T22	Willow Ck	12	8945	70	60000	1250	----**	----	----
T23	Skunk Ck	12	13316	40	134000	600	4	33	Not
T24	Silver Ck	7	3611	30	22000	340	----**	----**	----**
T25	Slip-Up Ck	11	16446	1000	62000	4200	----**	----	----
T26	W. Pipestone Ck	10	12350	700	64000	3850	----**	----	----
T27	W. Pipestone Ck	11	1814	60	7400	290	----**	----	----
T28	Pipestone Ck	11	5398	580	25000	1800	11	100	Not
T29	Pipestone Ck	11	1581	310	5000	1300	8	73	Not
T30	Split Rock Ck	11	6382	400	36000	1800	9	82	Not
T31	Split Rock Ck	11	20000	600	137000	1500	11	100	Not
T32	Beaver Ck	11	17150	160	96000	800	4	36	Not
T33	Beaver Ck	11	20427	120	172000	1300	5	46	Not
R01	BSR nr Brookings	12	296	60	690	230	0	0	Full
R02	BSR at Sinai Rd	10	1030	40	6800	305	1	10	Full
R03	BSR at Hwy 77	14	302	60	1200	225	0	0	Full
R04	BSR at USGS Brookings	10	2339	130	20000	355	1	10	Full
R05	BSR nr Flandreau	17	1004	0	15000	100	1	6	Full
R06	BSR at Egan	10	1316	40	8500	395	2	20	Full
R07	BSR at Trent	11	2206	50	17000	200	3	18	Full
R08	BSR at USGS Dell Rapids	23	2527	20	52000	110	7	30	Not
R09	BSR at Hwy 38A	19	4872	30	56000	200	6	32	Not
R10	BSR at Western Ave	11	2136	60	11000	520	6	55	Not
R11	BSR at USGS N. Cliff Ave	24	3208	40	31000	345	12	50	Not
R12	BSR at Brandon	16	2895	50	26000	275	7	44	Not
R13	BSR nr Gitchie Manitou	11	13426	130	117000	320	5	46	Not

Note for beneficial use (7) standard is 400 cfu/100mL; for beneficial use (8) is 2000 cfu/100mL

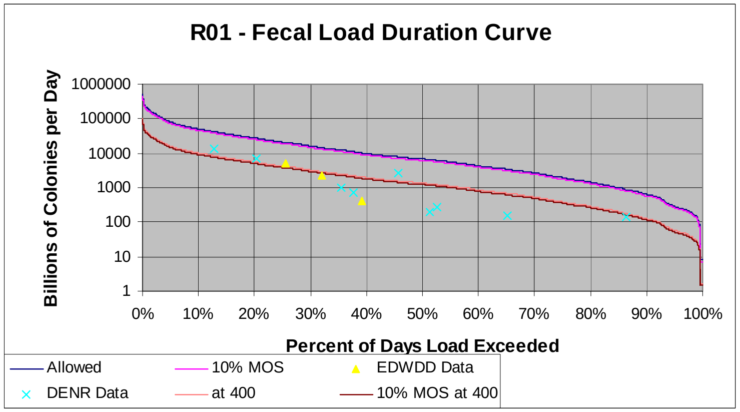
---- ** denotes no standard or beneficial used assigned for Fecals, but there are violations if a standard were applicable

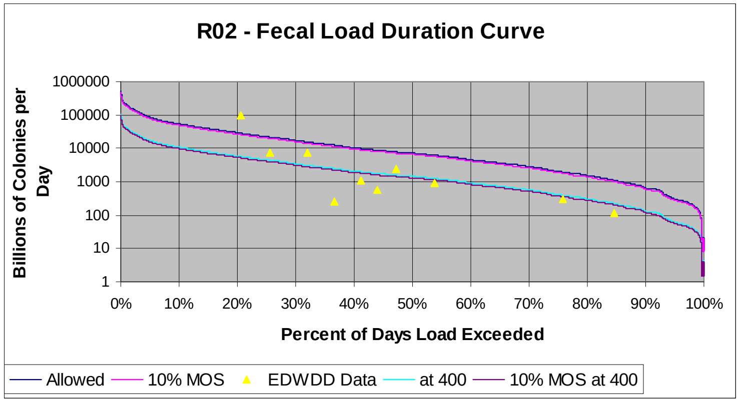
Total Suspended Solids mg/L

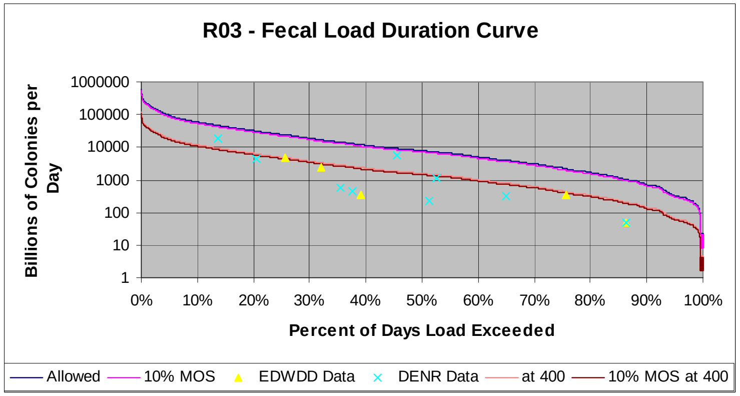
Site	Name	# of Sampl	Mean	Min	Max	Median	Violations of WQS	Percent Violating	Use Support
T01	N. Deer Ck	13	23	3	50	19	0	0	Full
T02	N. Deer Ck	10	41	2	186	10	0	0	Full
T03	Six Mile Ck	16	34	7	56	35	0	0	Full
T04	Six Mile Ck	19	60	4	436	33	1	5	Full
T05	Six Mile Ck	17	59	6	157	34	0	0	Full
T06	Deer Ck	14	75	4	394	25	1	7	Full
T07	Medary Ck	17	23	2	102	12	----	----	----
T08	Medary Ck	18	26	4	86	21	----	----	----
T09	Medary Ck	18	53	5	140	51	0	0	Full
T10	Outlet	9	55	7	206	29	----**	----	----
T11	Spring Ck	14	33	3	102	24	0	0	Full
T12	Flandreau Ck	15	61	5	308	24	2	13	Full
T13	Jack Moore Ck	14	25	2	67	17	0	0	Full
T14	Bachelor Ck	9	45	5	266	11	1	11	Full
T15	N. Buffalo Ck	16	75	8	324	43	----**	----	----
T16	Buffalo Ck	12	81	12	172	75	----**	----	----
T17	Brant Lk Outlet	15	19	3	67	11	0	0	Full
T18	Skunk Ck	16	73	11	200	49	0	0	Full
T19	Colton Ck	16	211	8	784	74	----**	----	----
T20	W. Branch Skunk	16	69	2	334	32	----**	----	----
T21	Skunk Ck	18	106	32	378	67	1	6	Full
T22	Willow Ck	17	84	8	408	54	----**	----	----
T23	Skunk Ck	18	122	30	684	74	1	6	Full
T24	Silver Ck	11	46	1	270	5	----**	----**	Full
T25	Slip-Up Ck	17	232	13	892	84	----**	----	----
T26	W. Pipestone Ck	14	77	4	249	59	----**	----	----
T27	W. Pipestone Ck	17	212	12	1088	50	----**	----	----
T28	Pipestone Ck	16	73	15	284	55	2	13	Full
T29	Pipestone Ck	16	65	11	156	54	0	0	Full
T30	Split Rock Ck	16	141	4	912	89	2	13	Full
T31	Split Rock Ck	16	178	16	972	66	3	19	Full
T32	Beaver Ck	17	286	14	1580	49	5	29	Not
T33	Beaver Ck	17	269	3	1312	77	5	29	Not
R01	BSR nr Brookings	51	78	4	314	56	7	14	Not
R02	BSR at Sinai Rd	15	123	38	213	100	6	40	Not
R03	BSR at Hwy 77	45	81	4	326	54	8	18	Not
R04	BSR at USGS Brookings	15	122	33	299	91	5	33	Not
R05	BSR nr Flandreau	53	79	0	444	62	6	11	Not
R06	BSR at Egan	14	105	20	220	92	3	21	Full
R07	BSR at Trent	15	122	30	270	105	3	20	Full
R08	BSR at USGS Dell Rapids	55	80	5	474	76	4	7	Full
R09	BSR at Hwy 38A	55	92	6	496	66	6	11	Not
R10	BSR at Western A	16	139	8	703	90	4	25	Full
R11	BSR at USGS N. Cliff Ave	54	103	3	513	74	9	17	Not
R12	BSR at Brandon	54	110	7	513	73	12	22	Not
R13	BSR nr Gitchie Manitou	16	228	19	1264	111	5	31	Not

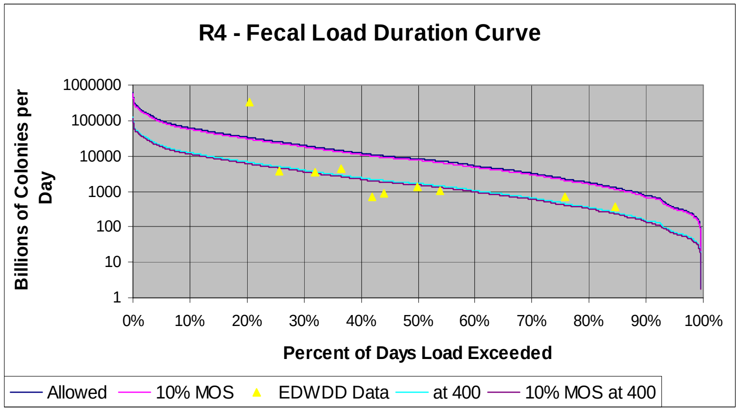
Note for beneficial use (5) standard is 158 mg/L; for beneficial use (6) standard is 263 mg/L
---- denotes no standard or beneficial used assigned for TSS, and no violations if they were applicable
---- ** denotes no standard or beneficial used assigned for TSS, but there are violations if standard were applicable

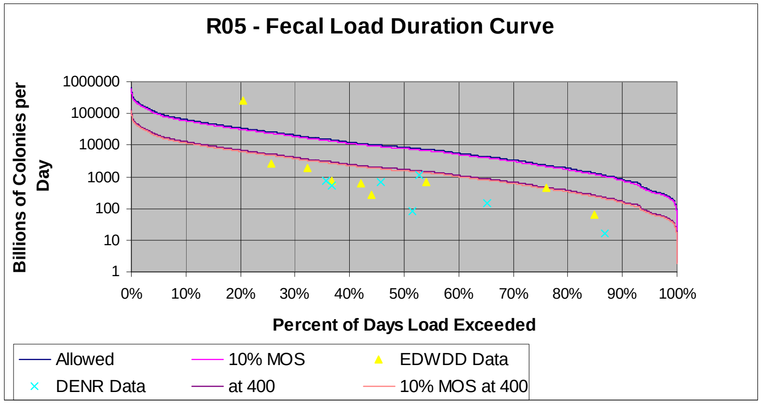
Appendix EE.
Fecal Load Duration Curves

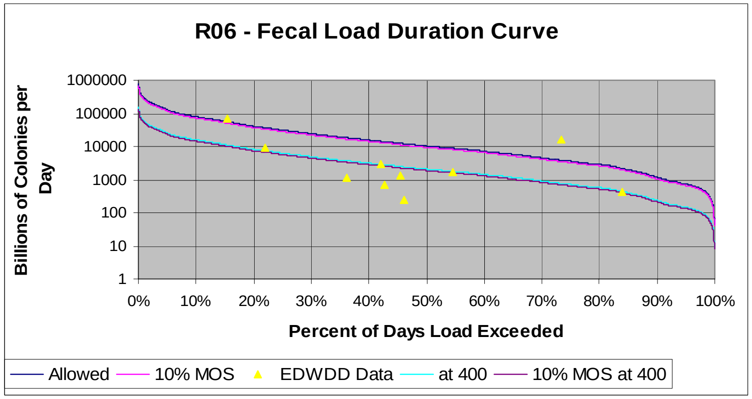

R01 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data
at 400
10% MOS at 400

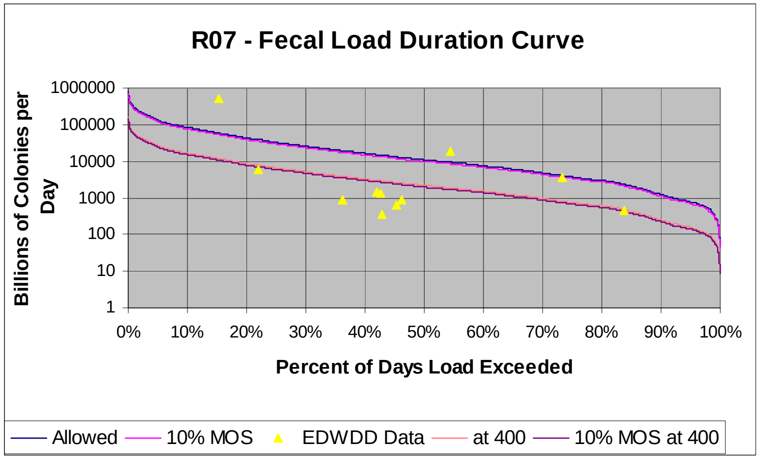

R02 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
at 400
10% MOS at 400

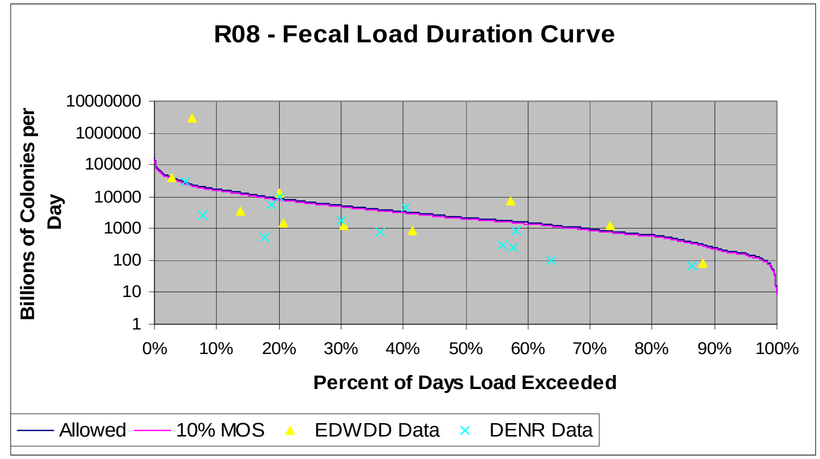

R03 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data
at 400
10% MOS at 400

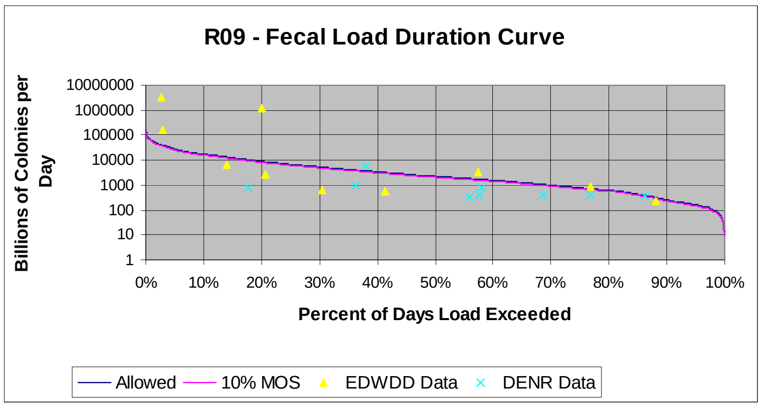

R4 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
at 400
10% MOS at 400

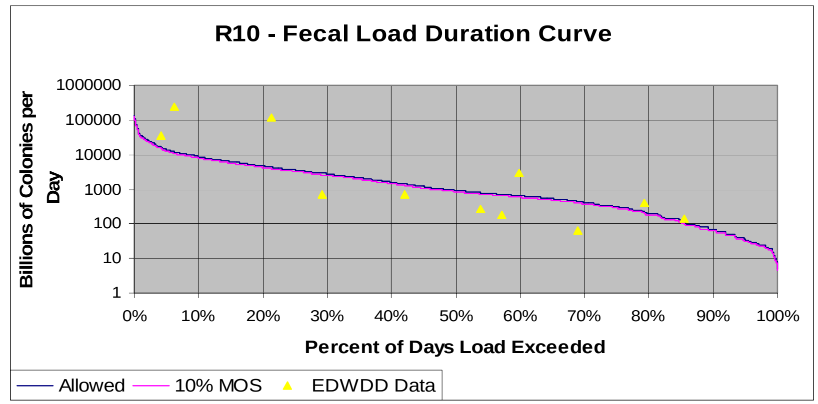

R05 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data
at 400
10% MOS at 400

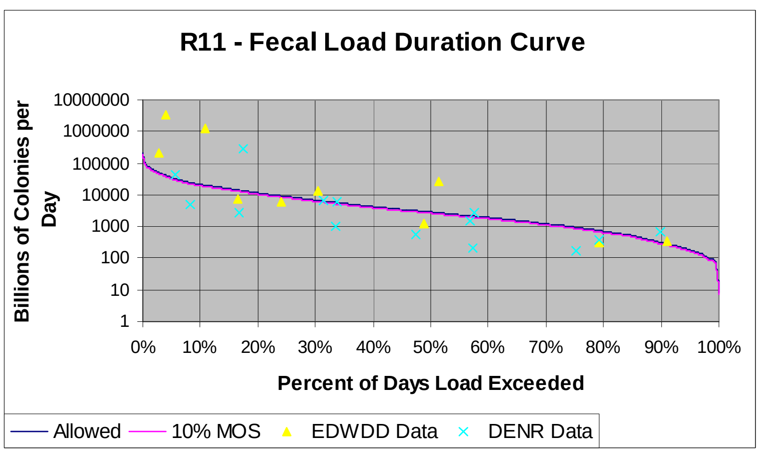

R06 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
at 400
10% MOS at 400

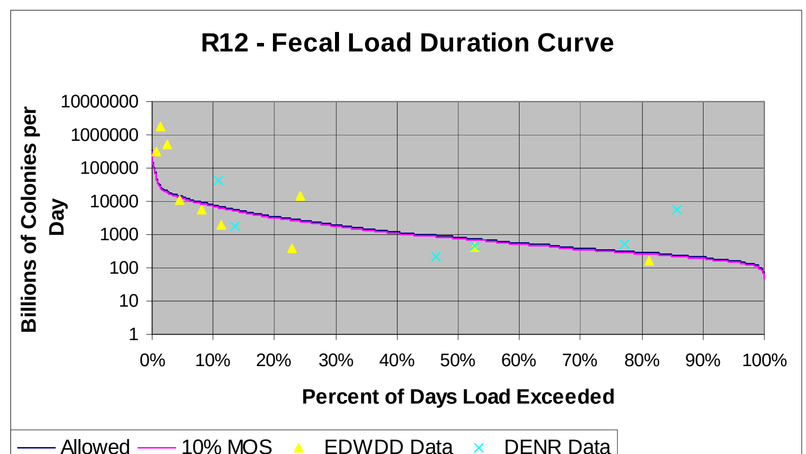

R07 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
at 400
10% MOS at 400

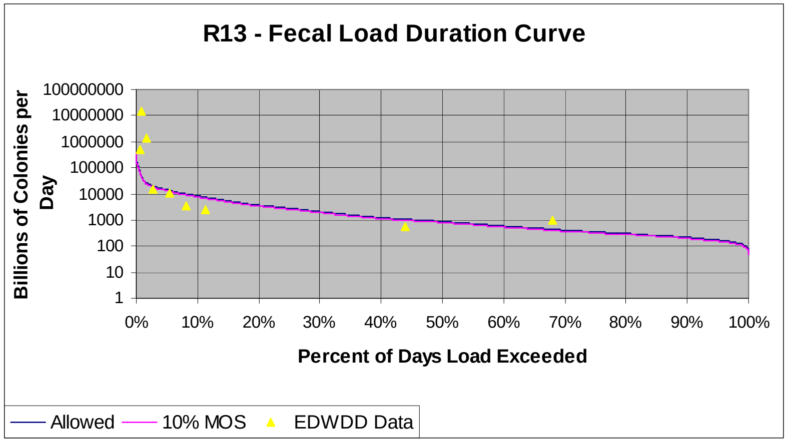

R08 - Fecal Load Duration Curve
Billions of Colonies per Day
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data


R09 - Fecal Load Duration Curve
Billions of Colonies per Day
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data


R10 - Fecal Load Duration Curve
Billions of Colonies per Day
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data


R11 - Fecal Load Duration Curve
Billions of Colonies per Day
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data


R12 - Fecal Load Duration Curve
Billions of Colonies per Day
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data


R13 - Fecal Load Duration Curve
Billions of Colonies per Day
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data

Appendix FF.
Fecal Coliform Bacteria Exceedences

Site	Location	Start Date	End Date	# of Samples	Min	Median	Max	Violations of WQS	Percent Violating	Numeric Standard	Use Support TMDL
T01	N. Deer Ck	Jul 99	Aug 00	9	30	500	1900	0	0	2000	Full
T02	N. Deer Ck	Jul 99	Jul 00	7	70	300	39000	2	29	2000	Not
T03	Six Mile Ck	Jul 99	Sep 00	11	10	200	1800	0	0	2000	Full
T04	Six Mile Ck	Jul 99	Sep 00	13	70	1700	67000	6	46	2000	Not
T05	Six Mile Ck	Jul 99	Aug 00	12	230	1850	30000	5	42	2000	Not
T06	Deer Ck	Jul 99	Aug 00	11	60	900	3300	1	9	2000	Full
T07	Medary Ck	Jul 99	Sep 00	12	60	1150	4600	---	---	---	---
T08	Medary Ck	Jul 99	Sep 00	13	80	730	9000	---	---	---	---
T09	Medary Ck	Jul 99	Sep 00	12	90	445	7200	2	17	2000	Full
T10	Lk Campbell Outlet	May 00	Sep 00	6	10	305	7200	---	---	---	---
T11	Spring Ck	Jul 99	Sep 00	11	270	1900	9000	5	46	2000	Not
T12	Flandreau Ck	Jul 99	Sep 00	11	270	1300	10000	4	36	2000	Not
T13	Jack Moore Ck	Jul 99	Sep 00	9	700	3200	19000	5	56	2000	Not
T14	Bachelor Ck	May 00	Sep 00	8	580	1150	55000	3	38	2000	Not
T15	N. Buffalo Ck	Jun 00	Sep 01	11	99	2800	16000	---	---	---	---
T16	Buffalo Ck	Jun 00	Jul 01	8	50	350	2200	---	---	---	---
T17	Brant Lk Outlet	Jun 00	Sep 01	10	80	160	9800	2	20	2000	Full
T18	Skunk Ck	Jun 00	Sep 01	11	100	1100	9100	4	36	2000	Not
T19	Colton Ck	Jun 00	Sep 01	11	300	4600	210000	---	---	---	---
T20	W. Branch Skunk Ck	Jun 00	Sep 01	11	800	2100	160000	---	---	---	---
T21	Skunk Ck	Jun 00	Sep 01	12	60	405	106000	2	17	2000	Full
T22	Willow Ck	Jun 00	Sep 01	12	70	1250	60000	---	---	---	---
T23	Skunk Ck	Jun 00	Sep 01	12	40	600	134000	4	33	2000	Not
T24	Silver Ck	May 01	Sep 01	7	30	340	22000	1	14	2000	Full
T25	Slip-Up Ck	Jun 00	Sep 01	11	1000	4200	62000	---	---	---	---
T26	W. Pipestone Ck	Jun 00	Sep 01	10	700	3850	64000	---	---	---	---
T27	W. Pipestone Ck	Jun 00	Sep 01	11	60	290	7400	---	---	---	---
T28	Pipestone Ck	Jun 00	Sep 01	11	580	1800	25000	11	100	400	Not
T29	Pipestone Ck	Jun 00	Sep 01	11	310	1300	5000	8	73	400	Not
T30	Split Rock Ck	Jun 00	Sep 01	11	400	1800	36000	9	82	400	Not
T31	Split Rock Ck	Jun 00	Sep 01	11	600	1500	137000	11	100	400	Not
T32	Beaver Ck	Jun 00	Sep 01	11	160	800	96000	4	36	2000	Not
T33	Beaver Ck	Jun 00	Sep 01	11	120	1300	172000	5	46	2000	Not

Summary of Fecal Coliform Bacteria Exceedences at Tributary and Mainstem Monitoring Sites Collected from 1999 to 2001

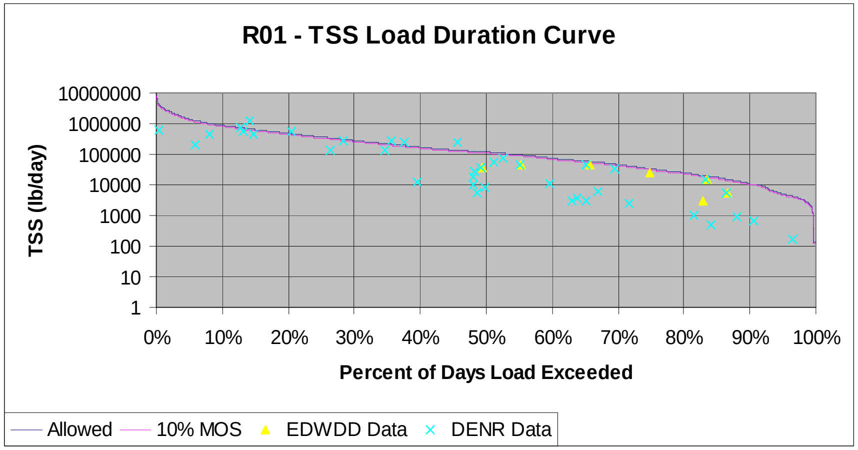
Site	Location	Start Date	End Date	# of Samples	Min	Median	Max	Violations of WQS	Percent Violating	Numeric Standard	Use Support TMDL
R01*	BSR nr Brookings	May 99	Sep 01	12	60	230	690	0	0	2000	Full
R02	BSR at Sinai Rd	Jul 99	Sep 00	10	40	305	6800	1	10	2000	Full
R03*	BSR at Hwy 77	May 99	Sep 00	14	60	225	1200	0	0	2000	Full
R04	BSR at USGS Brookings	Jul 99	Sep 00	10	130	355	20000	1	10	2000	Full
R05*	BSR nr Flandreau	May 99	Sep 00	17	0	100	15000	1	6	2000	Full
R06	BSR at Egan	Jul 99	Sep 00	10	40	395	8500	2	20	2000	Full
R07	BSR at Trent	Jul 99	Sep 00	11	50	200	17000	3	18	2000	Full
R08*	BSR at USGS Dell Rapids	May 00	Sep 01	23	20	110	52000	7	30	400	Not
R09*	BSR at Hwy 38A	May 00	Sep 01	19	30	200	56000	6	32	400	Not
R10	BSR at Western Ave	Jun 00	Sep 01	11	60	520	11000	6	55	400	Not
R11*	BSR at USGS N. Cliff Ave	May 00	Sep 01	24	40	345	31000	12	50	400	Not
R12*	BSR at Brandon	May 00	Sep 01	19	30	250	26000	8	42	400	Not
R13	BSR nr Gitchie Manitou	Jun 00	Sep 01	11	130	320	117000	5	46	400	Not

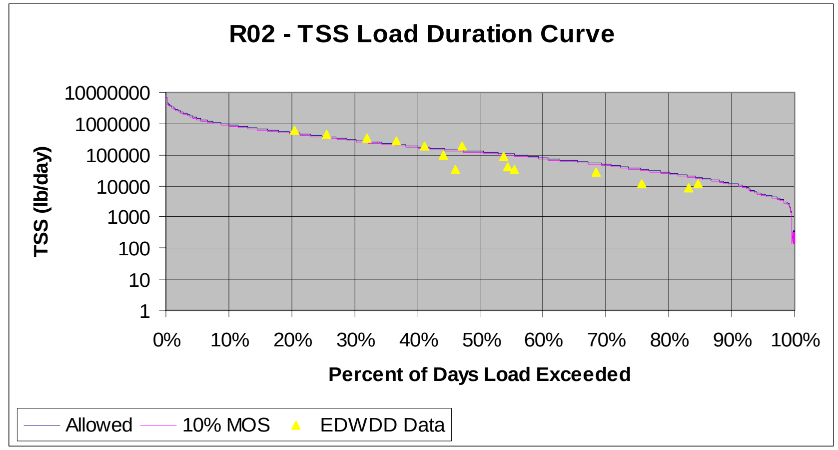
Note:

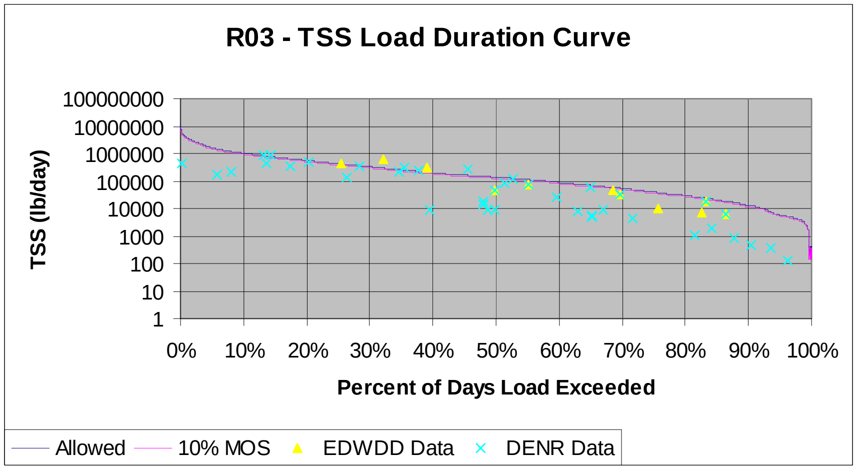
--- denotes beneficial use and/or standard has not been set for this site for this water quality parameter

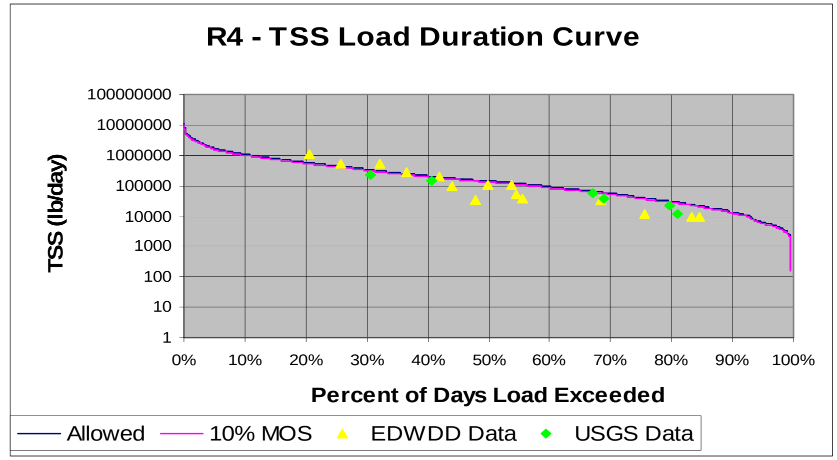
- SDDENR ambient WQ data included (includes May – Sept 1999-2001 data)

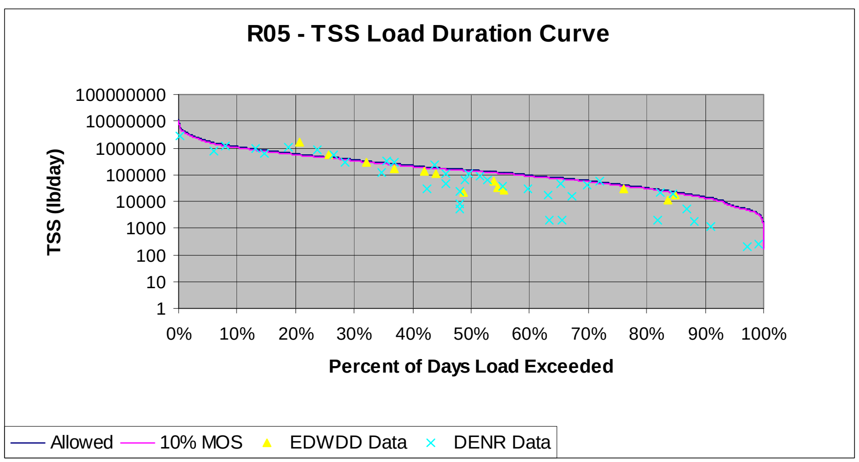
Appendix GG.
TSS Load Duration Curves

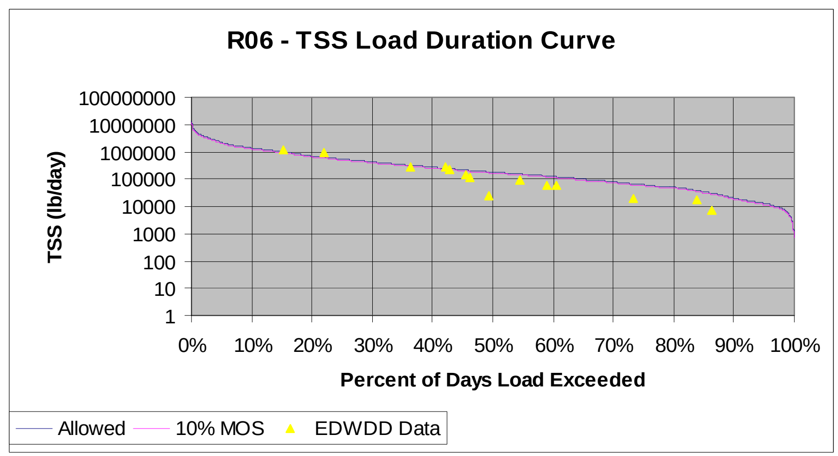

R01 - TSS Load Duration Curve
TSS (lb/day)
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data

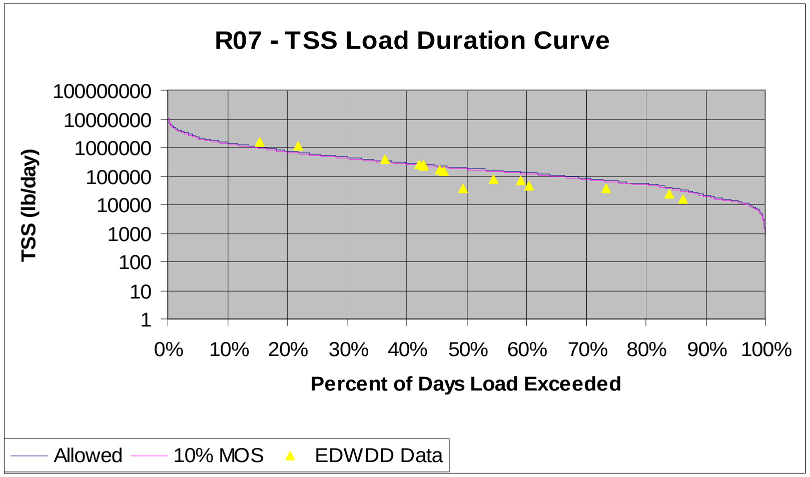

R02 - TSS Load Duration Curve
TSS (lb/day)
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data

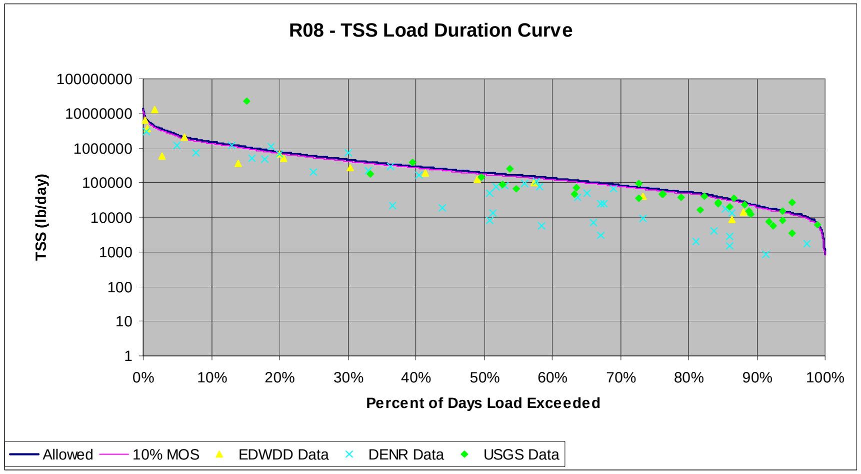

R03 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data

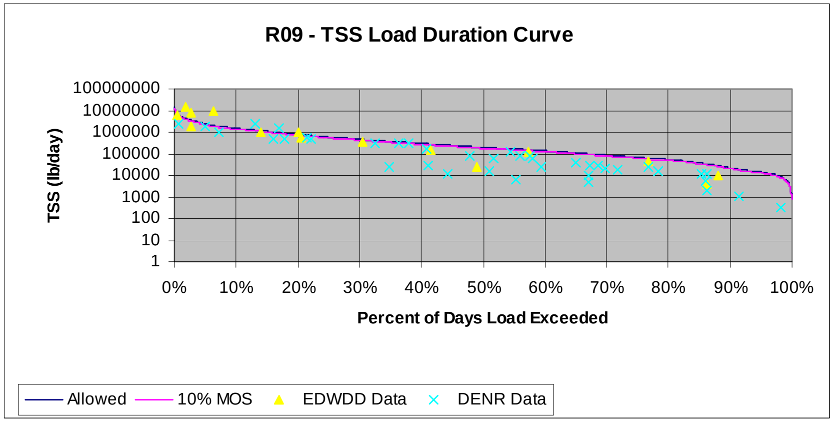

R4 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
USGS Data

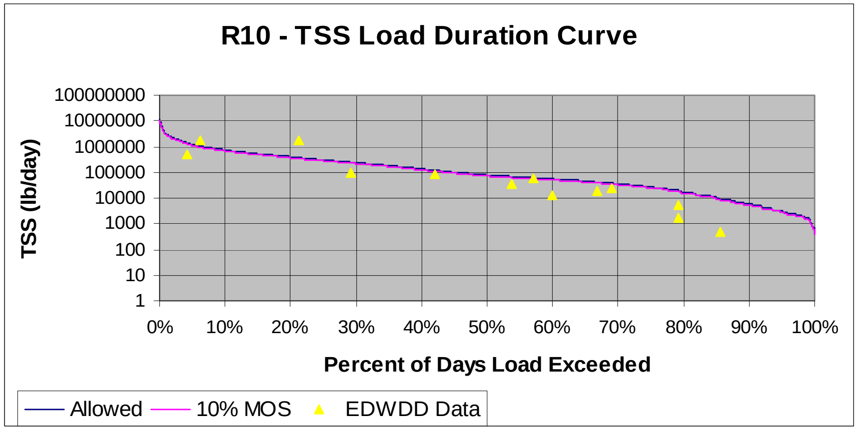

R05 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data

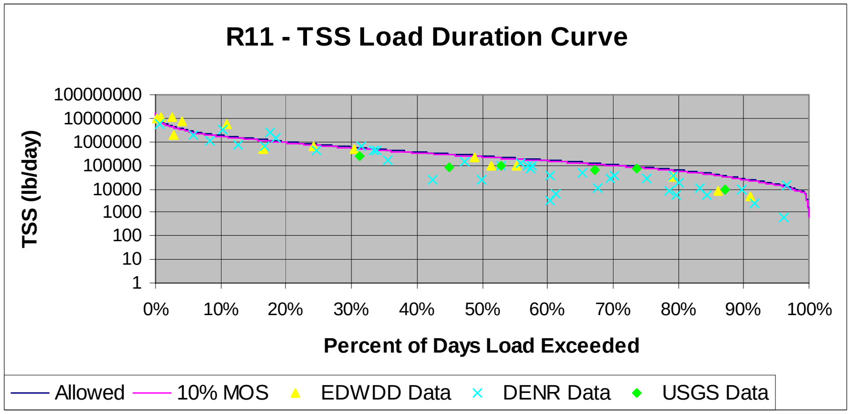

R06 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data

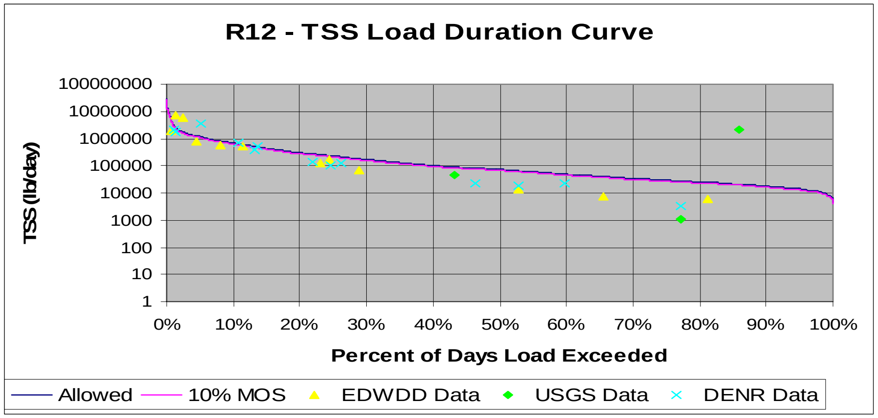

R07 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data

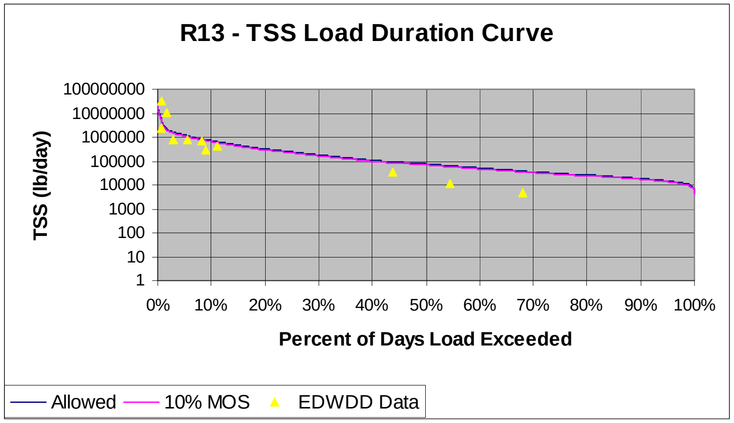

R08 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data
USGS Data


R09 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data


R10 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data


R11 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
DENR Data
USGS Data


R12 - TSS Load Duration Curve
TSS (lb/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data
USGS Data
DENR Data


R13 - TSS Load Duration Curve
100000000
10000000
1000000
100000
10000
1000
100
10
1
TSS (lb/day)
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Days Load Exceeded
Allowed
10% MOS
EDWDD Data

Appendix HH.
Total Suspended Solids Exceedences

Site	Location	Start Date	End Date	# of Samples	Min	Median	Max	Violations of WQS	Percent Violating	Numeric Standard	Use Support TMDL
T01	N. Deer Ck	Jul 99	Nov 00	13	3	19	50	0	0	263	Full
T02	N. Deer Ck	Jul 99	Nov 00	10	2	10	186	0	0	263	Full
T03	Six Mile Ck	Jul 99	Nov 00	16	7	35	56	0	0	263	Full
T04	Six Mile Ck	Jul 99	Nov 00	19	4	33	436	1	5	263	Full
T05	Six Mile Ck	Jul 99	Nov 00	17	6	34	157	0	0	263	Full
T06	Deer Ck	Jul 99	Aug 00	14	4	25	394	1	7	263	Full
T07	Medary Ck	Jul 99	Nov 00	17	2	12	102	---	---	---	---
T08	Medary Ck	Jul 99	Nov 00	18	4	21	86	---	---	---	---
T09	Medary Ck	Jul 99	Nov 00	18	5	51	140	0	0	263	Full
T10	Lk Campbell Outlet	Mar 00	Oct 00	9	7	29	206	---	---	---	---
T11	Spring Ck	Jul 99	Oct 00	14	3	24	102	0	0	263	Full
T12	Flandreau Ck	Jul 99	Oct 00	15	5	24	308	2	13	263	Full
T13	Jack Moore Ck	Jul 99	Oct 00	14	2	17	67	0	0	263	Full
T14	Bachelor Ck	May 00	Oct 00	9	5	11	266	1	11	263	Full
T15	N. Buffalo Ck	Jun 00	Oct 01	16	8	43	324	---	---	---	---
T16	Buffalo Ck	Jun 00	Jul 01	12	12	75	172	---	---	---	---
T17	Brant Lk Outlet	Jun 00	Oct 01	15	3	11	67	0	0	263	Full
T18	Skunk Ck	Jun 00	Oct 01	16	11	49	200	0	0	263	Full
T19	Colton Ck	Jun 00	Oct 01	16	8	74	784	---	---	---	---
T20	W. Branch Skunk Ck	Jun 00	Oct 01	16	2	32	334	---	---	---	---
T21	Skunk Ck	Jun 00	Oct 01	18	32	67	378	1	6	263	Full
T22	Willow Ck	Jun 00	Oct 01	17	8	54	408	---	---	---	---
T23	Skunk Ck	Jun 00	Oct 01	18	30	74	684	1	6	263	Full
T24	Silver Ck	Apr 01	Oct 01	11	1	5	270	1	9	263	Full
T25	Slip-Up Ck	Jun 00	Oct 01	17	13	84	892	---	---	---	---
T26	W. Pipestone Ck	Jun 00	Oct 01	14	4	59	249	---	---	---	---
T27	W. Pipestone Ck	Jun 00	Oct 01	17	12	50	1088	---	---	---	---
T28	Pipestone Ck	Jun 00	Oct 01	16	15	55	284	2	13	158	Full
T29	Pipestone Ck	Jun 00	Oct 01	16	11	54	156	0	0	158	Full
T30	Split Rock Ck	Jun 00	Oct 01	16	4	89	912	2	13	158	Full
T31	Split Rock Ck	Jun 00	Oct 01	16	16	66	972	4	25	158	Full
T32	Beaver Ck	Jun 00	Oct 01	17	14	49	1580	5	29	263	Not
T33	Beaver Ck	Jun 00	Oct 01	17	3	77	1312	5	29	263	Not

Summary of TSS Exceedences at Tributary and Mainstem Monitoring Sites Collected from 1999 to 2002

Site	Location	Start Date	End Date	# of Samples	Min	Median	Max	Violations of WQS	Percent Violating	Numeric Stnadard	Use Support TMDL
R01*	BSR nr Brookings	Jan 99	Apr 02	51	4	56	314	7	14	158	Not
R02	BSR at Sinai Rd	Jul 99	Nov 00	15	38	100	213	6	40	158	Not
R03*	BSR at Hwy 77	Jan 99	Apr 02	45	4	54	326	8	18	158	Not
R04	BSR at USGS Brookings	Jul 99	Sep 00	15	33	91	299	5	33	158	Not
R05*	BSR nr Flandreau	Jan 99	Apr 02	53	0	62	444	6	11	158	Not
R06	BSR at Egan	Jul 99	Oct 00	14	20	92	220	3	21	158	Full
R07	BSR at Trent	Jul 99	Oct 00	15	30	105	270	3	20	158	Full
R08*	BSR at USGS Dell Rapids	Jan 99	Apr 02	55	5	76	474	4	7	158	Full
R09*	BSR at Hwy 38A	Jan 99	Apr 02	55	6	66	496	6	11	158	Not
R10	BSR at Western Ave	Jan 99	Oct 01	16	8	90	703	4	25	158	Full
R11*	BSR at USGS N. Cliff Ave	Jul 00	Sep 02	54	3	74	513	9	17	158	Not
R12*	BSR at Brandon	Jan 99	Apr 02	54	7	73	513	12	22	158	Not
R13	BSR nr Gitchie Manitou	Jun 00	Oct 01	16	19	111	1264	5	31	158	Not

Note:
--- denotes beneficial use and/or numeric standard has not been set for this site for this water quality parameter
* SDDENR ambient WQ data included

Appendix II.
Fishes Collected During the CBSRWAP

Non-listed fish species collected during the Central Big Sioux River Watershed Assessment Project in 1999

Location	Six Mile Creek nr Flandreau, SD	Jack Moore Creek nr Egan, SD	Spring Creek nr Flandreau, SD	Deer Creek at Brookings, SD	Medary Creek nr Aurora, SD
County	Brookings	Moody	Moody	Brookings	Brookings
Date / Species	04-Aug-99	11-Augl-99	13-Aug-99	17-Aug-99	25-Aug-99
Black Bullhead	3	5	0	0	2
Bigmouth Shiner	10	2	104	120	422
Blacknose Dace	0	0	12	14	0
Bluntnose Minnow	0	0	23	135	51
Brassy Minnow	2	0	0	2	0
Common Shiner	14	36	156	33	146
Common Carp	1	0	0	0	0
Creek Chub	23	111	176	75	312
Fathead Minnow	12	0	0	43	9
Green Sunfish	2	9	0	0	8
Johnny Darter	7	32	20	0	47
Northern Pike	0	3	0	0	13
Orange spotted Sunfish	0	16	1	0	4
Red Shiner	77	2	7	46	113
Sand Shiner	95	22	43	443	686
Shorthead Redhorse	0	0	1	5	0
Stonecat	2	1	0	18	1
Stoneroller	8	6	75	7	391
Tadpole Madtom	0	0	0	0	2
White Sucker	2	8	138	23	345
Yellow Perch	7	0	0	0	0

Non-listed fish species collected during the Central Big Sioux River Watershed Assessment Project in 2000

Location	North Deer Creek nr Brookings, SD	Bachelor Creek nr Trent, SD	North Deer Creek nr White, SD	Six Mile Creek above Brookings, SD	Six Mile Creek below Brookings, SD	Medary Creek nr Elkton, SD	Medary Creek nr Brookings, SD	Lake Campbell Outlet	Slip-up Creek near Renner, SD
County	Brookings	Moody	Brookings	Brookings	Brookings	Brookings	Brookings	Brookings	Minnehaha
Date / Species	26-Jul-00	27-Jul-00	31-Jul-00	01-Aug-00	02-Aug-00	04-Aug-00	09-Aug-00	16-Aug-00	17-Aug-00
Black Bullhead	7	0	49	5	8	14	2	0	0
Bigmouth Shiner	432	513	26	324	7	140	381	0	447
Blacknose Dace	0	1	0	0	0	14	0	0	0
Bluntnose Minnow	0	0	0	0	0	13	40	0	799
Brassy Minnow	0	3	0	3	11	31	4	0	0
Brook Stickleback	0	3	1	0	0	2	0	0	0
Common Shiner	169	51	57	58	179	291	82	0	20
Common Carp	2	5	9	0	0	0	3	5	1
Creek Chub	222	93	49	73	11	211	249	0	170
Fathead Minnow	63	64	8	4	359	2	5	0	16
Green Sunfish	2	0	0	3	9	0	17	0	3
Iowa Darter	0	0	0	0	0	0	0	12	0
Johnny Darter	30	4	20	32	7	94	25	0	8
Northern Pike	0	0	0	0	0	1	3	0	0
Orange spotted Sunfish	0	0	0	0	61	0	8	0	0
Red Shiner	37	82	25	268	43	2	905	0	0
Sand Shiner	113	1520	5	429	7	40	838	0	52
Shorthead Redhorse	0	0	0	1	0	0	15	0	0
Stonecat	0	0	0	0	0	0	1	0	0
Stoneroller	6	2	1	1	29	131	9	0	60
Tadpole Madtom	0	0	4	3	1	1	2	0	0
White Sucker	58	67	2	26	99	44	120	0	23
Yellow Perch	7	0	0	0	0	0	0	0	0

Non-listed fish species collected during the Central Big Sioux River Watershed Assessment Project in 2001

Location	Willow Creek nr Sioux Falls, SD	Colton Creek nr Lyons, SD	North Buffalo Creek nr Chester, SD	W. Branch Skunk Creek nr Hartford, SD	W. Pipestone Creek Upper nr Sherman, SD	Buffalo Creek nr Chester, SD	Brant Lake Outlet nr Chester, SD	Beaver Creek Upper nr Valley Springs, SD	Pipestone Creek Upper nr Egan, SD
County	Minnehaha	Minnehaha	Lake	Minnehaha	Minnehaha	Lake	Lake	Minnehaha	Moody
Date / Species	27-Jun-01	28-Jun-01	02-Jul-01	03-Jul-01	05-Jul-01	11-Jul-01	12-Jul-01	13-Jul-01	16-Jul-01
Black Bullhead	19	0	2	0	3	664	0	0	0
Black Crappie	0	0	0	0	0	1	18	0	0
Bluegill	0	0	0	0	0	0	1	0	0
Bigmouth Shiner	1	8	2	5	0	0	0	5	55
Bluntnose Minnow	20	0	0	2	1	0	0	0	40
Common Shiner	12	0	0	31	11	0	0	2	122
Common Carp	0	0	0	0	6	51	1	1	0
Creek Chub	26	1	0	23	0	0	2	4	40
Fathead Minnow	0	1	0	0	0	1	0	0	3
Green Sunfish	1	1	0	0	1	2	0	0	0
Iowa Darter	11	0	0	0	0	0	0	0	0
Johnny Darter	0	1	0	4	7	2	0	0	1
Northern Pike	7	25	6	34	24	28	22	0	30
Orange spotted Sunfish	1	0	0	0	0	12	0	0	1
Red Shiner	21	69	31	21	0	0	0	24	273
River Carpsucker	0	0	0	0	0	0	0	0	4
Sand Shiner	24	216	601	141	4	0	0	41	323
Shorthead Redhorse	0	0	0	0	0	0	0	0	1
Stonecat	1	0	0	0	0	0	0	0	1
Stoneroller	0	0	0	0	1	0	0	0	54
Tadpole Madtom	0	0	0	3	0	0	0	0	0
White Bass	0	0	0	0	0	0	1	0	0
White Sucker	8	0	2	0	2	1	5	1	41
Yellow Perch	0	0	0	0	0	45	11	0	0

Non-listed fish species collected during the Central Big Sioux River Watershed Assessment Project in 2001

Location	Skunk Creek Upper NW of Dell Rapids, SD	Pipestone Creek Lower Sherman, SD	W. Pipestone Creek Lower nr Corson, SD	Skunk Ck Lower Sioux Falls, SD	Skunk Ck Middle Sioux Falls, SD	Split Rock Ck Upper nr Sherman, SD	Split Rock Ck Lower nr Corson, SD	Beaver Ck Lower nr Brandon, SD
County	Minnehaha	Minnehaha	Minnehaha	Minnehaha	Minnehaha	Minnehaha	Minnehaha	Minnehaha
Date / Species	26-Jul-01	31-Jul-01	02-Aug-01	09-Aug-01	10-Aug-01	15-Aug-01	16-Aug-01	17-Aug-01
Black Bullhead	1	2	0	8	0	1	0	5
Black Crappie	0	0	0	7	0	0	0	2
Bigmouth Shiner	15	42	288	4	23	4	1	35
Blacknose Dace	0	0	0	0	0	0	0	0
Bluntnose Minnow	0	121	110	51	68	38	30	29
Brassy Minnow	0	0	0	0	0	0	0	0
Brook Stickleback	0	0	0	0	0	0	0	0
Channel Catfish	0	0	1	2	28	1	5	27
Common Shiner	0	25	45	72	56	58	0	58
Common Carp	0	0	0	0	2	0	0	0
Creek Chub	17	13	46	46	11	5	0	0
Emerald Shiner	0	0	0	101	0	0	0	0
Fathead Minnow	36	35	9	24	25	4	0	1
Green Sunfish	0	0	0	0	0	0	0	3
Iowa Darter	3	1	0	0	0	0	0	0
Johnny Darter	3	4	69	2	11	15	135	2
Largemouth Bass	0	0	0	0	2	0	0	0
Northern Pike	28	11	3	47	14	4	9	2
Orange spotted Sunfish	2	39	0	14	5	0	9	20
Red Shiner	4	64	78	1929	693	385	36	96
River Carpsucker	0	2	1	0	0	3	0	6
Sand Shiner	30	367	219	513	779	62	28	64
Smallmouth Bass	0	0	9	0	0	0	9	0
Shorthead Redhorse	0	9	0	2	4	4	0	0
Stonecat	0	1	0	1	0	2	0	2
Stoneroller	0	12	20	3	0	5	2	3
Tadpole Madtom	1	0	1	0	0	0	0	1
Walleye	0	0	0	2	0	0	0	1
White Sucker	0	9	24	14	15	2	3	1
Yellow Perch	0	0	0	15	1	0	0	4

Locations of Topeka shiners collected during the CBSRWAP in 1999 and 2000.

Stream	Date	Legal Description	Numbers	Comments	Disposition
Medary Creek	8/25/99	T-110-N, R-48-W, NW ¼ of Sec. 32	2	1 mile east and 2 ½ S of Bushnell; east side of road.	Released in good condition
No Deer Creek	7/26/00	T-110-N, R-50-51-W, SW ¼ of S28	1	At point both 2 miles W of Brookings and 2 miles S of Highway 14	Released in good condition
Six Mile Creek	8/2/00	T-111-N, R-48-W, SW ¼ of Sec. 6	311	½ mile north of White, SD; east side of road	Released in good condition
Medary Creek	8/8/00, 8/9/00	T-109-N, R-49-W, SE ¼ of S19	1 each day	1 ¼ miles north of Elkton on west side of road	Released in good condition
Medary Creek	8/9/00	T-109-N, R-47-W, SE ¼ of Sec. 8	1	13 miles west of Elkton and ½ mile south; on east side of I-29	Released in good condition

Locations of Topeka shiners collected during the CBSRWAP in 2001

Stream	Date	Legal Description	Numbers	Comments	Disposition
W. Pipestone Creek	7/5/01	T103N, R48W, NW1/4 of Sec 1	2	3 ½ miles west of Sherman on south side of 250th street	Released in good condition
Pipestone Creek	7/16/01	T106N, R47W, NE1/4 of Sec 33 and NW1/4 of Sec 34	2	6 miles south of Flandreau and 6 miles east	Released in good condition
Beaver Creek	8/17/01	T101N, R48W, SW1/4 of Sec 10	1	½ mile south of Brandon city limits and ½ mile east on north side of road	Released in good condition

Locations of Trout Perch collected during the CBSRWAP in 2001

Stream	Date	Legal Description	Numbers	Comments	Disposition
Split Rock Creek Lower	8/16/01	T102N, R48W, SW1/4 of Sec 15	1	1 ½ miles north of I90 on County 11 and ½ mile west on 259th street on north side of road	Released in good condition
Beaver Creek Lower	8/17/01	T101N, R48W, SW1/4 of Sec 10	24	½ mile south of Brandon and ½ mile east on north side of road	Released in good condition

Locations of Blackside Darter collected during the CBSRWAP in 2001

Stream	Date	Legal Description	Numbers	Comments	Disposition
Split Rock Creek Upper	8/15/01	T103N, R47W, SW1/4 of Sec 3	1	1 ½ miles north of I90 on County 11 and ½ mile west on 259th street on north side of road	Released in good condition
Split Rock Creek Lower	8/16/01	T102N, R48W, SW1/4 of Sec 15	7	1 mile north and ½ mile west of Corson, upstream from road	Released in good condition
W. Pipestone Creek Lower	8/2/01	T102N, R48W, NE1/4 of Sec 3	7	4 miles north of I90 on County 11 on west side of road	Released in good condition
Pipestone Creek Lower	7/31/01	T104N, R47W, SW1/4 of Sec 8	1	½ mile south of Brandon on County 115 and ½ mile east on 264th street on north side of road	Released in good condition
Beaver Creek Lower	8/17/01	T101N, R48W, SW1/4 of Sec 10	1	½ mile south of Brandon and ½ mile east on north side of road	Released in good condition

Appendix JJ.
Life History Designations for Fishes Found During the CBSRWAP

Life History Designations for Fishes Found During CBSRWAP

Common Name	Scientific name	Trophic	Tolerance	Sensitive	Habitat Guild (B or WC)	Headwater	Pioneer	Simple Lithophil
Carps and Minnows	**Cyprinidae**							
Central stoneroller	*Campostoma anomalum*	H	M		B	H	p	
Red shiner	*Cyprinella lutrensis*	I	T		G			
Common carp	*Cyprinus carpio*	O	T		B			
Brassy minnow	*Hybognathus hankinsoni*	H	M		G			
Common shiner	***Luxilus cornutus***	I	M		WC			SL
Emerald shiner	*Notropis atherinoides*	I	M		WC			SL
Bigmouth shiner	*Notropis dorsalis*	I	M		B			
Sand shiner	*Notropis stramineus*	I	M		WC			
Topeka shiner	*Notropis topeka*	I	I	S	WC			
Bluntnose minnow	*Pimephales notatus*	O	T		G		P	
Fathead minnow	*Pimephales promelas*	O	T		G		P	
Blacknose dace	*Rhinichthys atratulus*	I	M		B	H		SL
Creek chub	*Semotilus atromaculatus*	I	T		WC		P	
Suckers	*Catostomidae*							
River carpsucker	*Carpiodes carpio*	O	M		B			
White sucker	*Catostomus commersoni*	O	T		B			SL
Shorthead redhorse	*Moxostoma macrolepidotum*	I	M	S	B			SL
Bullhead/Catfishes	**Ictaluridae**							
Black bullhead	*Ameiurus melas*	I	M		B		P	
Channel catfish	*Ictalurus punctatus*	I	M		B			
Stonecat	*Noturus flavus*	I	I	S	B			
Tadpole madtom	*Noturus gyrinus*	I	M	S	B			
Pikes	**Esocidae**							
Northern pike	*Esox lucius*	P	M		WC			
Trout-perches	**Percopsidae**							
Trout-perch	*Percopsis omiscomaycus*	I	M	S	B			
Sticklebacks	**Gasterosteidae**							
Brook stickleback	*Culaea inconstans*	I	M	S	WC	H		
Temperate Basses	**Perichthyidae**							
White bass	*Morone chrysops*	P	M		WC			
Sunfishes	**Centrarchidae**							
Green sunfish	*Lepomis cyanellus*	I	T		WC		P	
Orangespotted sunfish	*Lepomis humilis*	I	M		WC			
Bluegill	*Lepomis macrochirus*	I	M		WC			
Smallmouth bass	*Micropterus dolomieu*	P	M		WC			
Largemouth bass	*Micropterus salmoides*	P	M		WC			
Black crappie	*Pomoxis nigromaculatus*	P	M		WC			
Perches	**Percidae**							
Iowa darter	*Etheostoma exile*	I	I	S	B	H		
Johnny darter	*Etheostoma nigrum*	I	M		B	H	P	
Yellow perch	*Perca flavescens*	I	M		WC			
Blackside darter	*Percina maculata*	I	M		B			SL
Walleye	*Stizostedion vitreum*	P	M		B			SL

Trophic	Tolerance	Habitat Guild
H = Herbivore	I = Intolerant	B = Benthic
I = Insectivore	M = Moderately Tolerant	G = Generalist
O = Omnivore	T = Tolerant	WC = Water Column
P = Predator		

Appendix KK.
Candidate Metric Results for Fishes

SiteID	Species Richness	Native Species Richness	Native Minnow Richness	WaterColumn Species Richness	Benthic Species Richness	Benthic Insectivore Richness	HeadWater Species Richness	% HeadWater Species	% HeadWater BIOMASS	% Pioneer Species
T01	12	11	6	3	7	4	3	11.055	1.771	63.819
T02	14	13	8	6	6	3	2	3.133	2.426	28.721
T03	15	15	9	6	6	4	2	3.152	3.802	37.040
T04	14	14	8	4	7	5	2	2.683	0.940	9.593
T05	14	13	8	5	6	4	2	5.660	2.990	21.132
T06	13	13	10	3	6	4	2	2.106	1.607	26.078
T07	16	16	10	5	7	5	4	23.375	16.876	45.102
T08	17	17	9	7	8	6	3	23.283	8.423	36.034
T09	20	19	10	7	9	6	2	1.254	0.886	12.800
T10	2	1	0	0	2	1	1	70.588	70.000	0.000
T11	11	11	8	4	5	3	3	14.153	13.325	38.889
T13	13	13	6	6	6	4	2	19.388	5.634	54.082
T14	13	12	9	4	6	3	4	0.415	0.259	6.766
T15	6	6	3	2	3	2	0	0.000	0.000	0.311
T16	10	8	1	5	4	2	1	0.248	0.015	82.900
T17	8	4	1	6	2	0	0	0.000	0.000	3.279
T18	11	11	5	4	5	5	2	4.286	0.143	40.714
T19	8	8	5	4	2	2	1	0.311	0.103	1.242
T20	9	9	6	4	3	3	1	1.515	0.035	10.985
T21	16	15	7	7	6	4	1	0.633	0.228	6.621
T22	13	13	6	6	5	4	1	7.237	0.464	43.421
T23	20	19	9	8	9	6	2	0.175	0.054	4.690
T25	11	10	7	4	5	2	2	4.253	3.181	66.041
T26	11	10	5	5	5	2	2	12.903	0.169	20.968
T27	16	15	8	5	8	5	2	9.570	2.400	27.312
T28	16	16	9	6	7	4	2	5.550	1.573	13.925
T29	18	18	8	5	10	7	3	2.243	0.217	24.670
T30	17	17	8	4	10	7	2	3.367	0.186	11.448
T31	13	12	6	4	7	5	2	49.818	10.428	60.727
T32	7	6	5	3	3	1	0	0.000	0.000	5.128
T33	23	27	9	10	13	9	2	1.289	0.065	11.082

SiteID	% Pioneer Species BIOMASS	Intolerant Species RICHNESS	% Intolerant Species	% Intolerant Species BIOMASS	Sensitive Species Richness	% Sensitive Species	% Sensitive Species BIOMASS	% Green Sunfish	% Green Sunfish BIOMASS	% Tolerant Species
T01	82.126	0			2	2.513	0.805	0.000		71.357
T02	26.752	1	0.087	0.067	1	0.087	0.067	0.174	0.067	34.030
T03	30.501	1	27.233	11.074	2	27.320	11.240	0.788	3.449	46.322
T04	19.205	0	0.000	0.000	2	0.325	1.097	0.244	1.083	30.813
T05	43.182	1	0.755	0.359	1	0.755	0.359	0.755	0.239	44.906
T06	30.883	1	1.805	2.928	2	2.307	6.824	0.000	0.000	32.297
T07	42.283	0	0.000	0.000	2	0.291	0.026	0.000	0.000	27.740
T08	37.054	2	0.951	0.203	3	2.501	0.420	0.282	0.459	29.271
T09	9.903	2	0.111	0.029	4	0.738	40.021	0.627	0.305	49.465
T10	0.000	1	70.588	70.000	1	70.588	70.000	0.000	0.000	29.412
T11	47.526	0	0.000	0.000	0	0.000	0.000	0.000	0.000	45.503
T13	48.698	1	0.510	0.043	1	0.510	0.043	4.592	5.634	39.796
T14	14.659	0	0.000	0.000	1	0.125	0.043	0.000	0.000	12.910
T15	6.936	0	0.000	0.000	0	0.000	0.000	0.000	0.000	5.435
T16	86.619	0	0.000	0.000	0	0.000	0.000	0.248	0.305	89.095
T17	2.364	0	0.000	0.000	0	0.000	0.000	0.000	0.000	13.115
T18	45.172	1	2.143	0.048	2	2.857	0.096	0.000	0.000	41.429
T19	0.821	0	0.000	0.000	0	0.000	0.000	0.311	0.513	22.360
T20	34.454	0	0.000	0.000	1	1.136	1.050	0.000	0.000	17.424
T21	2.556	0	0.000	0.000	1	0.230	22.948	0.000	0.000	46.862
T22	70.754	2	7.895	1.044	2	7.895	1.044	0.658	0.387	62.500
T23	12.839	1	0.035	0.781	2	0.105	7.961	0.000	0.000	72.524
T25	61.614	0	0.000	0.000	0	0.000	0.000	0.188	0.744	63.290
T26	7.504	1	3.226	0.253	1	3.226	0.253	1.613	1.686	20.968
T27	16.461	0	0.000	0.000	1	0.108	0.025	0.000	0.000	28.710
T28	18.676	2	0.303	0.291	3	0.404	0.699	0.000	0.000	40.061
T29	15.516	2	0.264	0.279	3	1.451	14.370	0.000	0.000	32.190
T30	9.629	1	0.337	1.907	2	1.010	24.631	0.000	0.000	73.232
T31	16.590	0	0.000	0.000	1	0.364	0.316	0.000	0.000	25.091
T32	32.450	0	0.000	0.000	0	0.000	0.000	0.000	0.000	38.462
T33	9.188	2	0.773	1.026	4	7.216	1.921	0.773	0.044	34.794

SiteID	% Insectivorous minnows	% Insectivorous minnows BIOMASS	% Insectivores	% Insectivores BIOMASS	% Predator	% Predator BIOMASS	% Omnivore	% Omnivore BIOMASS	% Herbivore
T01	52.764	16.586	89.950	90.177	0.000		9.548	9.662	0.503
T02	84.769	85.108	88.773	91.105	0.000	0.000	10.705	8.288	0.522
T03	48.862	30.584	56.392	43.736	0.000	0.000	40.105	52.358	3.503
T04	93.659	50.321	97.236	54.039	0.000	0.000	2.439	45.818	0.325
T05	83.019	85.526	91.321	95.335	0.000	0.000	4.906	1.794	3.774
T06	76.630	69.029	78.937	75.853	0.000	0.000	20.160	23.729	0.903
T07	67.701	61.838	78.468	63.826	0.097	1.229	5.723	19.913	15.713
T08	59.845	53.179	71.821	56.460	0.458	5.015	13.913	31.990	13.808
T09	90.631	38.393	93.213	81.775	0.111	6.551	6.197	11.484	0.480
T10	0.000	0.000	70.588	70.000	0.000	0.000	29.412	30.000	0.000
T11	66.005	61.092	68.783	61.964	0.000	0.000	21.296	26.124	9.921
T13	59.184	58.899	91.327	76.910	1.531	5.420	4.082	13.487	3.061
T14	93.815	91.178	94.105	91.286	0.000	0.000	5.645	8.368	0.249
T15	98.447	71.965	98.758	78.902	0.932	16.763	0.311	4.335	0.000
T16	0.000	0.000	89.839	89.411	3.594	7.186	6.568	3.403	0.000
T17	3.279	2.364	22.951	16.050	67.213	56.538	9.836	27.411	0.000
T18	47.143	41.778	54.286	47.849	20.000	51.769	25.714	0.382	0.000
T19	91.304	46.817	91.925	47.433	7.764	52.464	0.311	0.103	0.000
T20	83.712	65.616	86.364	66.702	12.879	33.228	0.758	0.070	0.000
T21	89.925	38.736	92.746	63.924	0.921	9.732	6.333	26.343	0.000
T22	55.263	46.692	76.974	80.155	4.605	3.714	18.421	16.132	0.000
T23	93.280	30.615	94.820	50.634	1.960	41.448	3.115	7.877	0.105
T25	43.089	44.967	43.777	45.982	0.000	0.000	52.470	51.108	3.752
T26	27.419	20.911	45.161	28.078	38.710	41.737	14.516	30.101	1.613
T27	72.688	35.236	81.075	36.868	1.290	7.962	15.484	54.153	2.151
T28	82.240	45.564	82.644	46.496	3.027	20.326	8.880	31.683	5.449
T29	67.414	32.549	74.934	52.028	1.451	15.082	22.032	32.766	1.583
T30	86.532	22.631	90.572	50.401	0.673	4.396	7.912	45.156	0.842
T31	23.636	10.412	80.727	31.585	6.545	61.463	12.000	6.794	0.727
T32	97.436	99.338	97.436	99.338	0.000	0.000	2.564	0.662	0.000
T33	65.464	3.928	88.402	65.103	1.289	3.885	9.536	30.969	0.773

SiteID	% Herbivore BIOMASS	% Simple Lithophil	% Simple Lithophil BIOMASS
T01	0.161	1.005	0.644
T02	0.606	19.756	21.024
T03	3.906	24.343	53.044
T04	0.142	6.911	60.493
T05	2.871	5.283	13.756
T06	0.418	10.832	34.008
T07	15.033	33.851	48.750
T08	6.536	17.718	44.573
T09	0.190	8.004	56.523
T10	0.000	0.000	0.000
T11	11.912	40.608	47.376
T13	4.183	22.449	39.522
T14	0.346	4.940	13.838
T15	0.000	0.311	4.335
T16	0.000	0.124	0.015
T17	0.000	8.197	27.411
T18	0.000	0.000	0.000
T19	0.000	0.000	0.000
T20	0.000	11.742	21.499
T21	0.000	4.318	53.475
T22	0.000	13.158	20.309
T23	0.042	6.685	26.238
T25	2.910	2.689	22.196
T26	0.084	20.968	28.752
T27	1.016	8.172	41.504
T28	1.495	16.549	40.148
T29	0.124	5.805	36.327
T30	0.047	10.943	32.201
T31	0.158	3.636	1.738
T32	0.000	3.846	5.960
T33	0.044	15.722	0.808

Appendix LL.
Candidate Metric Results for Macroinvertebrates

Natural Resource Solutions and Ecoanalyst, Inc. Results by Metric

Metric 5		Metric 6		Metric 7		Metric 8	
StationID	Ephem Richness	StationID	Trichop Richness	StationID	Pleco Richness	StationID	Diptera Richness
R01	7	R01	6	R01	0	R01	17
R02	4	R02	7	R02	1	R02	14
R03	5	R03	5	R03	0	R03	12
R04	6	R04	6	R04	0	R04	12
R05	1	R05	1	R05	0	R05	4
R06	5	R06	6	R06	0	R06	9
R07	5	R07	5	R07	1	R07	11
R08	10	R08	6	R08	1	R08	9
R09	9	R09	4	R09	2	R09	10
R10	5	R10	7	R10	1	R10	9
R11	5	R11	8	R11	0	R11	17
R12	10	R12	7	R12	2	R12	10
R13	8	R13	7	R13	0	R13	10
T04	2	T04	0	T04	0	T04	27
T05	7	T05	6	T05	0	T05	15
T06	9	T06	4	T06	0	T06	16
T07	3	T07	3	T07	0	T07	15
T08	8	T08	2	T08	0	T08	17
T08	3	T08	1	T08	0	T08	20
T09	5	T09	3	T09	0	T09	26
T10	0	T10	1	T10	0	T10	13
T11	8	T11	6	T11	0	T11	11
T11	6	T11	1	T11	0	T11	26
T12	7	T12	6	T12	0	T12	18
T13	4	T13	3	T13	0	T13	15
T13	1	T13	0	T13	0	T13	22
T14	1	T14	1	T14	0	T14	25
T15	4	T15	2	T15	0	T15	13
T17	1	T17	1	T17	0	T17	4
T18	7	T18	1	T18	0	T18	5
T19	5	T19	5	T19	0	T19	12
T19	4	T19	2	T19	0	T19	10
T19	4	T19	3	T19	0	T19	8
T20	1	T20	4	T20	0	T20	8
T20	3	T20	3	T20	0	T20	6
T20	4	T20	2	T20	0	T20	5
T21	9	T21	6	T21	0	T21	6
T22	4	T22	3	T22	0	T22	9
T22	3	T22	2	T22	0	T22	4
T22	4	T22	1	T22	0	T22	4
T23	7	T23	6	T23	0	T23	10
T24	2	T24	1	T24	0	T24	8
T25	3	T25	1	T25		T25	21
T26	5	T26	1	T26	0	T26	14
T27	6	T27	6	T27	0	T27	15
T28	7	T28	6	T28	0	T28	13
T28	8	T28	4	T28	0	T28	12
T28	8	T28	4	T28	0	T28	10
T29	6	T29	3	T29	1	T29	8
T30	5	T30	8	T30	0	T30	5
T30	6	T30	6	T30	0	T30	11
T30	6	T30	3	T30	0	T30	7
T31	10	T31	5	T31	1	T31	9
T32	10	T32	7	T32	0	T32	9
T33	9	T33	6	T33	2	T33	9
T33	8	T33	7	T33	0	T33	8
T33	5	T33	7	T33	3	T33	7

Metric 1		Metric 2		Metric 3		Metric 4	
StationID	**Corrected Abundance**	StationID	**EPT Abundance**	StationID	**Taxa Richness**	StationID	**EPT Richness**
R01	8400	R01	3930	R01	31	R01	13
R02	8070	R02	4590	R02	27	R02	12
R03	5580	R03	1140	R03	24	R03	10
R04	9690	R04	4200	R04	26	R04	12
R05	14000	R05	80	R05	7	R05	2
R06	7880	R06	7340	R06	22	R06	11
R07	4455	R07	1140	R07	24	R07	11
R08	1952	R08	222	R08	34	R08	17
R09	1075	R09	96	R09	34	R09	15
R10	2018	R10	276	R10	25	R10	13
R11	514	R11	89	R11	36	R11	13
R12	1558	R12	251	R12	31	R12	19
R13	1683	R13	170	R13	36	R13	15
T04	2890	T04	30	T04	33	T04	2
T05	9330	T05	2340	T05	31	T05	13
T06	13080	T06	6160	T06	30	T06	13
T07	2288	T07	233	T07	28	T07	6
T08	38400	T08	14160	T08	30	T08	10
T08	3580	T08	550	T08	29	T08	4
T09	11760	T09	720	T09	42	T09	8
T10	138	T10	1	T10	17	T10	1
T11	7752	T11	4560	T11	27	T11	14
T11	2528	T11	1003	T11	37	T11	7
T12	3312	T12	1116	T12	36	T12	13
T13	11680	T13	4280	T13	27	T13	7
T13	4335	T13	345	T13	30	T13	1
T14	3250	T14	180	T14	33	T14	2
T15	1790	T15	73	T15	34	T15	6
T17	874	T17	18	T17	21	T17	2
T18	578	T18	32	T18	29	T18	8
T19	547	T19	77	T19	33	T19	10
T19	301	T19	76	T19	23	T19	6
T19	316	T19	63	T19	17	T19	7
T20	1280	T20	238	T20	21	T20	5
T20	1952	T20	155	T20	25	T20	6
T20	1577	T20	205	T20	21	T20	6
T21	1260	T21	258	T21	35	T21	15
T22	872	T22	197	T22	27	T22	7
T22	1103	T22	45	T22	19	T22	5
T22	554	T22	212	T22	17	T22	5
T23	2042	T23	294	T23	29	T23	13
T24	495	T24	117	T24	27	T24	3
T25	1600	T25	385	T25	31	T25	4
T26	1898	T26	125	T26	31	T26	6
T27	509	T27	173	T27	39	T27	12
T28	955	T28	229	T28	39	T28	13
T28	1060	T28	198	T28	32	T28	12
T28	589	T28	130	T28	31	T28	12
T29	3976	T29	221	T29	23	T29	10
T30	1416	T30	315	T30	26	T30	13
T30	698	T30	231	T30	35	T30	12
T30	1856	T30	293	T30	18	T30	9
T31	1452	T31	217	T31	29	T31	16
T32	572	T32	256	T32	33	T32	17
T33	3699	T33	243	T33	32	T33	17
T33	1922	T33	253	T33	29	T33	15
T33	1384	T33	290	T33	28	T33	15

Metric 9	
StationID	Chiro Richness
R01	6
R02	6
R03	7
R04	10
R05	3
R06	6
R07	8
R08	8
R09	9
R10	8
R11	13
R12	7
R13	9
T04	18
T05	10
T06	10
T07	7
T08	13
T08	14
T09	13
T10	7
T11	8
T11	19
T12	14
T13	10
T13	9
T14	13
T15	11
T17	3
T18	4
T19	10
T19	9
T19	7
T20	8
T20	6
T20	5
T21	6
T22	7
T22	3
T22	3
T23	9
T24	7
T25	14
T26	13
T27	11
T28	11
T28	10
T28	9
T29	7
T30	5
T30	9
T30	7
T31	9
T32	5
T33	6
T33	6
T33	5

Metric 10	
StationID	EPT/Chiro Abund.
R01	46.79
R02	59.61
R03	6.30
R04	27.45
R05	0.25
R06	431.76
R07	6.33
R08	3.04
R09	0.57
R10	15.33
R11	0.95
R12	7.61
R13	3.04
T04	0.20
T05	12.72
T06	48.50
T07	1.45
T08	77.80
T08	3.72
T09	11.43
T10	0.02
T11	74.75
T11	6.34
T12	12.68
T13	31.24
T13	9.32
T14	3.16
T15	0.71
T17	2.00
T18	2.00
T19	1.04
T19	1.13
T19	1.58
T20	8.50
T20	1.91
T20	4.36
T21	16.13
T22	11.59
T22	0.26
T22	53.00
T23	10.89
T24	6.16
T25	3.74
T26	1.08
T27	2.19
T28	6.19
T28	5.66
T28	4.81
T29	14.73
T30	24.23
T30	5.92
T30	41.86
T31	5.56
T32	23.27
T33	10.13
T33	8.43
T33	15.26

Metric 11	
StationID	% EPT
R01	46.79
R02	56.88
R03	20.43
R04	43.34
R05	0.57
R06	93.15
R07	25.59
R08	68.10
R09	30.57
R10	81.90
R11	27.73
R12	77.47
R13	48.57
T04	1.04
T05	25.08
T06	47.09
T07	10.16
T08	36.88
T08	15.36
T09	6.12
T10	0.72
T11	58.82
T11	39.66
T12	33.70
T13	36.64
T13	7.96
T14	5.54
T15	7.03
T17	6.19
T18	9.55
T19	24.29
T19	25.25
T19	21.88
T20	74.38
T20	47.55
T20	62.50
T21	81.90
T22	60.24
T22	13.98
T22	65.63
T23	86.22
T24	35.45
T25	24.06
T26	39.43
T27	37.04
T28	72.70
T28	62.26
T28	40.75
T29	66.97
T30	88.98
T30	66.19
T30	94.52
T31	71.85
T32	82.85
T33	79.15
T33	78.82
T33	83.82

Metric 12	
StationID	% Ephemeroptera
R01	10.71
R02	4.46
R03	5.02
R04	3.41
R05	0.29
R06	23.35
R07	8.42
R08	34.36
R09	12.10
R10	10.98
R11	11.84
R12	37.04
R13	35.14
T04	1.04
T05	13.50
T06	30.28
T07	7.54
T08	32.19
T08	15.08
T09	4.76
T10	0.00
T11	39.94
T11	32.20
T12	16.30
T13	14.73
T13	7.96
T14	5.23
T15	5.11
T17	5.84
T18	6.27
T19	20.19
T19	22.59
T19	20.14
T20	64.69
T20	27.30
T20	61.28
T21	39.37
T22	55.96
T22	13.35
T22	65.33
T23	21.99
T24	35.15
T25	23.44
T26	37.85
T27	17.99
T28	26.98
T28	28.62
T28	25.39
T29	12.42
T30	53.95
T30	43.55
T30	13.55
T31	33.77
T32	25.24
T33	19.54
T33	19.00
T33	20.81

Metric 13	
StationID	% Plecoptera
R01	0.00
R02	0.37
R03	0.00
R04	0.00
R05	0.00
R06	0.00
R07	0.67
R08	0.31
R09	0.64
R10	0.30
R11	0.00
R12	2.16
R13	0.00
T04	0.00
T05	0.00
T06	0.00
T07	0.00
T08	0.00
T08	0.00
T09	0.00
T10	0.00
T11	0.00
T11	0.00
T12	0.00
T13	0.00
T13	0.00
T14	0.00
T15	0.00
T17	0.00
T18	0.00
T19	0.00
T19	0.00
T19	0.00
T20	0.00
T20	0.00
T20	0.00
T21	0.00
T22	0.00
T22	0.00
T22	0.00
T23	0.00
T24	0.00
T25	0.00
T26	0.00
T27	0.00
T28	0.00
T28	0.00
T28	0.00
T29	0.30
T30	0.00
T30	0.00
T30	0.00
T31	0.66
T32	0.00
T33	0.98
T33	0.00
T33	0.87

Metric 14	
StationID	% Trichoptera
R01	36.07
R02	52.04
R03	15.41
R04	39.94
R05	0.29
R06	69.80
R07	16.50
R08	33.44
R09	17.83
R10	70.62
R11	15.89
R12	38.27
R13	13.43
T04	0.00
T05	11.58
T06	16.82
T07	2.62
T08	4.69
T08	0.28
T09	1.36
T10	0.72
T11	18.89
T11	7.46
T12	17.39
T13	21.92
T13	0.00
T14	0.31
T15	1.93
T17	0.34
T18	3.28
T19	4.10
T19	2.66
T19	1.74
T20	9.69
T20	20.25
T20	1.22
T21	42.54
T22	4.28
T22	0.62
T22	0.31
T23	64.22
T24	0.30
T25	0.63
T26	1.58
T27	19.06
T28	45.71
T28	33.65
T28	15.36
T29	54.24
T30	35.03
T30	22.64
T30	80.97
T31	37.42
T32	57.61
T33	58.63
T33	59.81
T33	62.14

Metric 15	
StationID	% Coleoptera
R01	0.71
R02	2.60
R03	2.87
R04	3.10
R05	0.86
R06	1.27
R07	11.45
R08	0.92
R09	4.78
R10	10.09
R11	0.00
R12	6.79
R13	4.00
T04	2.77
T05	7.07
T06	0.00
T07	16.39
T08	3.75
T08	8.94
T09	4.76
T10	1.45
T11	19.81
T11	1.02
T12	15.22
T13	4.11
T13	28.72
T14	44.62
T15	60.40
T17	3.44
T18	2.99
T19	19.56
T19	21.59
T19	27.78
T20	5.63
T20	12.88
T20	9.15
T21	5.71
T22	24.16
T22	25.78
T22	25.39
T23	2.35
T24	2.12
T25	11.88
T26	4.73
T27	36.19
T28	8.25
T28	17.61
T28	40.13
T29	27.58
T30	2.26
T30	10.60
T30	2.26
T31	14.57
T32	6.80
T33	2.93
T33	2.80
T33	4.62

Metric 16	
StationID	% Diptera
R01	31.43
R02	30.86
R03	67.38
R04	52.94
R05	98.57
R06	4.82
R07	62.63
R08	28.22
R09	59.24
R10	8.01
R11	48.60
R12	15.43
R13	29.14
T04	55.71
T05	62.06
T06	43.12
T07	53.77
T08	57.19
T08	45.25
T09	23.47
T10	56.52
T11	19.20
T11	54.92
T12	33.70
T13	47.60
T13	14.88
T14	24.92
T15	17.15
T17	4.12
T18	5.07
T19	49.53
T19	46.84
T19	49.31
T20	8.75
T20	24.85
T20	14.33
T21	5.08
T22	6.73
T22	54.97
T22	3.10
T23	9.97
T24	12.42
T25	34.69
T26	36.91
T27	22.27
T28	12.70
T28	13.84
T28	9.40
T29	4.85
T30	3.67
T30	11.75
T30	2.26
T31	12.91
T32	8.74
T33	13.68
T33	16.20
T33	10.12

Metric 17	
StationID	% **Oligochaeta**
R01	20.36
R02	9.67
R03	8.60
R04	0.00
R05	0.00
R06	0.00
R07	0.00
R08	0.31
R09	4.14
R10	0.00
R11	18.38
R12	0.00
R13	4.86
T04	30.45
T05	1.29
T06	8.26
T07	0.98
T08	0.94
T08	0.00
T09	48.64
T10	15.94
T11	0.00
T11	1.36
T12	0.00
T13	0.00
T13	26.64
T14	17.23
T15	9.63
T17	30.93
T18	13.73
T19	3.15
T19	4.98
T19	1.04
T20	0.00
T20	0.31
T20	6.10
T21	0.63
T22	0.61
T22	2.48
T22	0.62
T23	0.59
T24	5.15
T25	15.31
T26	0.63
T27	1.28
T28	2.54
T28	1.89
T28	4.08
T29	0.00
T30	0.56
T30	4.58
T30	0.00
T31	0.00
T32	0.00
T33	1.63
T33	0.31
T33	0.00

Metric 18	
StationID	% Baetidae
R01	0.36
R02	1.49
R03	0.00
R04	0.31
R05	0.00
R06	0.25
R07	0.00
R08	0.31
R09	0
R10	0.89
R11	2.8
R12	1.23
R13	0.57
T04	0.00
T05	2.25
T06	22.02
T07	0.00
T08	3.75
T08	0.00
T09	0.00
T10	0.00
T11	28.17
T11	0.00
T12	0.36
T13	8.56
T13	0.00
T14	0.00
T15	0
T17	0
T18	0
T19	0.32
T19	0
T19	0.35
T20	0
T20	0
T20	0
T21	2.54
T22	0
T22	0
T22	0
T23	3.52
T24	0
T25	0.00
T26	0
T27	0
T28	0
T28	0
T28	0
T29	0
T30	0
T30	0
T30	1.29
T31	0
T32	0.97
T33	2.61
T33	1.87
T33	0.06

Metric 19	
StationID	% Hydropsychidae
R01	35.36
R02	51.30
R03	15.41
R04	39.94
R05	0.29
R06	69.54
R07	14.81
R08	4.91
R09	1.91
R10	25.22
R11	0.93
R12	14.81
R13	1.71
T04	0.00
T05	5.47
T06	9.17
T07	0.00
T08	4.38
T08	0.00
T09	1.02
T10	0.72
T11	13.62
T11	0.00
T12	6.88
T13	21.58
T13	0.00
T14	0.00
T15	0.00
T17	0.00
T18	0.00
T19	1.26
T19	0.00
T19	0.69
T20	4.38
T20	11.66
T20	0.30
T21	24.44
T22	2.14
T22	0.31
T22	0.31
T23	34.90
T24	0.00
T25	0.63
T26	1.58
T27	9.42
T28	12.38
T28	3.77
T28	1.57
T29	6.67
T30	18.36
T30	10.60
T30	64.52
T31	27.48
T32	14.56
T33	33.55
T33	13.71
T33	23.12

Metric 20	
StationID	% **Chironomidae**
R01	30.00
R02	28.62
R03	64.87
R04	47.37
R05	97.43
R06	4.31
R07	60.61
R08	22.39
R09	53.82
R10	5.34
R11	29.28
R12	10.19
R13	16.00
T04	51.21
T05	59.16
T06	38.84
T07	52.46
T08	56.88
T08	41.34
T09	21.43
T10	36.23
T11	18.89
T11	53.56
T12	32.25
T13	46.92
T13	12.80
T14	17.54
T15	9.92
T17	3.09
T18	4.78
T19	23.34
T19	22.26
T19	13.89
T20	8.75
T20	24.85
T20	14.33
T21	5.08
T22	5.20
T22	52.80
T22	1.24
T23	7.92
T24	5.76
T25	32.19
T26	36.59
T27	16.92
T28	11.75
T28	11.01
T28	8.46
T29	4.55
T30	3.67
T30	11.17
T30	2.26
T31	12.91
T32	3.56
T33	7.82
T33	9.35
T33	5.49

Metric 21	
StationID	% Gastropoda
R01*	0.71
R02*	1.12
R03*	0.00
R04*	4.95
R05*	0.00
R06*	0.25
R07*	0.00
R08	0.31
R09	0.32
R10	0.00
R11	0.00
R12	0.00
R13	0.00
T04*	0.00
T05*	0.00
T06*	0.31
T07*	0.00
T08*	0.31
T08*	0.00
T09*	0.00
T10*	0.00
T11*	0.00
T11*	0.68
T12*	0.00
T13*	0.34
T13*	0.00
T14*	0.00
T15	4.34
T17	17.87
T18	19.10
T19	2.21
T19	0.33
T19	0.00
T20	6.25
T20	7.98
T20	2.74
T21	0.00
T22	1.22
T22	0.00
T22	0.31
T23	0.00
T24	19.70
T25*	0.31
T26	12.62
T27	1.71
T28	1.90
T28	0.94
T28	0.63
T29	0.00
T30	0.85
T30	2.29
T30	0.00
T31	0.00
T32	0.00
T33	0.00
T33	0.00
T33	0.00

* Metric 21 - % Simuliidae was used

Metric 22			
StationID	**ShanWeaver (log e)**	**ShanWeaver (log 2)**	**ShanWeaver (log 10)**
R01	2.71	3.91	1.18
R02	2.56	3.69	1.11
R03	2.17	3.13	0.94
R04	2.48	3.58	1.08
R05	0.22	0.32	0.10
R06	1.89	2.72	0.82
R07	2.22	3.20	0.96
R08	2.74	3.95	1.19
R09	2.46	3.55	1.07
R10	2.30	3.31	1.00
R11	2.71	3.91	1.18
R12	2.91	4.20	1.27
R13	2.96	4.26	1.28
T04	2.67	3.85	1.16
T05	2.66	3.83	1.15
T06	2.72	3.92	1.18
T07	2.46	3.55	1.07
T08	2.62	3.78	1.14
T08	2.56	3.69	1.11
T09	2.90	4.18	1.26
T10	2.09	3.02	0.91
T11	2.43	3.50	1.05
T11	2.82	4.07	1.22
T12	2.97	4.28	1.29
T13	2.31	3.34	1.00
T13	2.51	3.62	1.09
T14	2.34	3.37	1.02
T15	1.71	2.47	0.74
T17	2.23	3.22	0.97
T18	2.24	3.24	0.97
T19	2.50	3.61	1.09
T19	2.36	3.41	1.03
T19	1.87	2.70	0.81
T20	1.56	2.25	0.68
T20	2.50	3.60	1.09
T20	2.05	2.96	0.89
T21	2.73	3.94	1.18
T22	2.32	3.35	1.01
T22	1.49	2.14	0.65
T22	1.89	2.73	0.82
T23	2.36	3.41	1.03
T24	2.45	3.54	1.07
T25	2.79	4.03	1.21
T26	2.55	3.67	1.11
T27	2.83	4.08	1.23
T28	2.81	4.05	1.22
T28	2.63	3.80	1.14
T28	2.47	3.56	1.07
T29	1.93	2.79	0.84
T30	2.08	3.00	0.90
T30	2.85	4.11	1.24
T30	1.64	2.37	0.71
T31	2.47	3.57	1.07
T32	2.56	3.70	1.11
T33	2.52	3.64	1.10
T33	2.47	3.56	1.07
T33	2.42	3.49	1.05

Metric 23	
StationID	No. Intolerant Taxa
R01	5
R02	4
R03	3
R04	2
R05	0
R06	5
R07	3
R08	5
R09	5
R10	5
R11	4
R12	6
R13	4
T04	0
T05	3
T06	4
T07	1
T08	0
T08	3
T09	0
T10	0
T11	0
T11	3
T12	1
T13	0
T13	0
T14	0
T15	0
T17	0
T18	0
T19	1
T19	1
T19	1
T20	0
T20	0
T20	0
T21	5
T22	0
T22	1
T22	0
T23	3
T24	0
T25	0
T26	0
T27	2
T28	1
T28	1
T28	0
T29	1
T30	1
T30	2
T30	1
T31	1
T32	5
T33	6
T33	6
T33	9

Metric 24	
StationID	% Tolerant Organisms
R01	36.79
R02	20.82
R03	40.50
R04	41.49
R05	97.43
R06	2.54
R07	57.91
R08	12.27
R09	50.96
R10	5.04
R11	41.43
R12	6.79
R13	30.57
T04	79.93
T05	13.50
T06	13.98
T07	72.10
T08	80.50
T08	22.19
T09	37.76
T10	51.45
T11	67.12
T11	11.76
T12	39.64
T13	15.75
T13	61.59
T14	41.54
T15	27.26
T17	92.78
T18	85.67
T19	39.12
T19	37.21
T19	23.96
T20	11.88
T20	16.56
T20	37.50
T21	6.67
T22	25.99
T22	67.70
T22	28.17
T23	6.74
T24	84.55
T25	63.13
T26	78.23
T27	25.48
T28	10.79
T28	14.78
T28	17.87
T29	1.52
T30	8.76
T30	14.33
T30	0.97
T31	12.58
T32	4.85
T33	3.91
T33	4.36
T33	1.45

Metric 25	
StationID	% Burrowers
R01	
R02	
R03	
R04	
R05	
R06	
R07	
R08	11.66
R09	40.76
R10	0.00
R11	2.49
R12	1.85
R13	11.43
T04	
T05	
T06	
T07	
T08	
T08	
T09	
T10	
T11	
T11	
T12	
T13	
T13	
T14	
T15	4.72
T17	0.34
T18	2.09
T19	10.41
T19	5.32
T19	6.60
T20	0.00
T20	0.00
T20	0.61
T21	2.86
T22	0.00
T22	0.62
T22	0.62
T23	2.93
T24	0.61
T25	
T26	22.40
T27	4.28
T28	0.32
T28	0.31
T28	0.00
T29	0.30
T30	0.85
T30	4.01
T30	0.00
T31	2.98
T32	0.00
T33	0.00
T33	0.31
T33	0.00

Metric 26	
StationID	Hilsenhoff Biotic Index
R01	6.36
R02	5.64
R03	7.54
R04	6.14
R05	7.96
R06	4.27
R07	7.01
R08	5.09
R09	7.21
R10	4.88
R11	6.71
R12	4.83
R13	6.01
T04	8.48
T05	5.47
T06	5.62
T07	6.15
T08	5.60
T08	7.09
T09	7.23
T10	7.15
T11	5.56
T11	6.53
T12	5.74
T13	5.92
T13	7.72
T14	7.02
T15	6.75
T17	8.39
T18	7.95
T19	6.89
T19	6.65
T19	6.36
T20	4.85
T20	5.59
T20	5.67
T21	4.80
T22	5.50
T22	8.29
T22	5.54
T23	4.97
T24	7.61
T25	7.10
T26	7.57
T27	6.00
T28	5.02
T28	5.16
T28	5.67
T29	4.72
T30	4.70
T30	5.27
T30	5.29
T31	5.30
T32	4.70
T33	4.71
T33	4.46
T33	4.32

Metric 27		Metric 28		Metric 29	
StationID	**% Dominant Taxon**	StationID	**% Hydropsychidae / Trichop**	StationID	**% Baetidae / Ephem**
R01*	20.00	R01	0.98	R01	0.03
R02*	21.19	R02	0.99	R02	0.33
R03*	40.50	R03	1.00	R03	5.02
R04*	25.70	R04	1.00	R04	0.09
R05*	96.29	R05	1.00	R05	0.29
R06*	32.74	R06	1.00	R06	0.01
R07*	31.31	R07	0.90	R07	8.42
R08	13.50	R08	14.68	R08	0.89
R09	36.94	R09	10.71	R09	0.00
R10	30.56	R10	35.71	R10	8.11
R11	18.07	R11	5.88	R11	23.68
R12	11.42	R12	38.71	R12	3.33
R13	13.14	R13	12.77	R13	1.63
T04*	26.99	T04	0.00	T04	1.04
T05*	21.86	T05	0.47	T05	0.17
T06*	20.49	T06	0.55	T06	0.73
T07*	28.52	T07	2.62	T07	7.54
T08*	14.69	T08	0.93	T08	0.12
T08*	20.67	T08	0.28	T08	15.08
T09*	26.19	T09	0.75	T09	4.76
T10*	23.19	T10	0.00	T10	0.00
T11*	27.86	T11	0.72	T11	0.71
T11*	22.37	T11	7.46	T11	32.20
T12*	13.04	T12	0.40	T12	0.02
T13*	29.11	T13	0.98	T13	0.58
T13*	28.72	T13	0.00	T13	7.96
T14*	43.38	T14	0.31	T14	5.23
T15	59.63	T15	0.00	T15	0.00
T17	28.18	T17	0.00	T17	0.00
T18	37.61	T18	0.00	T18	0.00
T19	25.87	T19	30.77	T19	1.56
T19	24.58	T19	0.00	T19	0.00
T19	35.42	T19	40.00	T19	1.72
T20	64.69	T20	45.16	T20	0.00
T20	20.86	T20	57.58	T20	0.00
T20	43.90	T20	25.00	T20	0.00
T21	20.32	T21	57.46	T21	6.45
T22	24.77	T22	50.00	T22	0.00
T22	51.55	T22	50.00	T22	0.00
T22	28.17	T22	100.00	T22	0.00
T23	31.96	T23	54.34	T23	16.00
T24	34.55	T24	0.00	T24	0.00
T25*	15.31	T25	1.00	T25	23.44
T26	29.97	T26	100.00	T26	0.00
T27	23.98	T27	49.44	T27	0.00
T28	26.35	T28	27.08	T28	0.00
T28	27.67	T28	11.21	T28	0.00
T28	38.24	T28	10.20	T28	0.00
T29	44.55	T29	12.29	T29	0.00
T30	43.50	T30	52.42	T30	0.00
T30	24.36	T30	46.84	T30	0.00
T30	46.13	T30	79.68	T30	9.52
T31	25.83	T31	73.45	T31	0.00
T32	31.72	T32	25.28	T32	3.85
T33	30.29	T33	57.22	T33	13.33
T33	33.96	T33	22.92	T33	9.84
T33	26.30	T33	37.21	T33	30.56

* Metric 27 - % 1 dominant taxon used

Metric 30		Metric 31		Metric 32		Metric 33	
StationID	**% Gatherers+Filterers**	StationID	**% Gatherers**	StationID	**% Filterers**	StationID	**% Shredders**
R01	82.14	R01	46.07	R01	36.07	R01	7.14
R02	77.70	R02	24.91	R02	52.79	R02	13.01
R03	84.95	R03	68.82	R03	16.13	R03	1.43
R04	80.81	R04	34.37	R04	46.44	R04	9.91
R05	97.72	R05	97.43	R05	0.29	R05	0.00
R06	74.62	R06	3.05	R06	71.57	R06	0.51
R07	71.72	R07	56.23	R07	15.49	R07	2.02
R08	42.02	R08	17.48	R08	24.54	R08	14.11
R09	56.69	R09	53.50	R09	3.18	R09	15.61
R10	85.76	R10	10.39	R10	75.37	R10	0.30
R11	56.39	R11	33.33	R11	23.05	R11	8.10
R12	54.63	R12	10.49	R12	44.14	R12	0.31
R13	39.14	R13	34.29	R13	4.86	R13	10.86
T04	80.62	T04	71.97	T04	8.65	T04	1.73
T05	32.47	T05	25.40	T05	7.07	T05	31.83
T06	74.00	T06	62.69	T06	11.31	T06	9.48
T07	81.97	T07	60.66	T07	21.31	T07	0.33
T08	64.69	T08	42.81	T08	21.88	T08	15.63
T08	84.36	T08	62.29	T08	22.07	T08	0.84
T09	65.98	T09	58.16	T09	7.82	T09	2.04
T10	33.33	T10	32.61	T10	0.72	T10	23.19
T11	58.51	T11	44.27	T11	14.24	T11	10.22
T11	71.19	T11	63.73	T11	7.46	T11	1.69
T12	33.69	T12	15.94	T12	17.75	T12	10.51
T13	54.45	T13	23.29	T13	31.16	T13	29.45
T13	82.70	T13	73.01	T13	9.69	T13	0.69
T14	76.92	T14	70.77	T14	6.15	T14	1.23
T15	74.95	T15	74.76	T15	0.19	T15	1.83
T17	70.45	T17	68.04	T17	2.41	T17	0.00
T18	65.07	T18	57.01	T18	8.06	T18	0.90
T19	55.84	T19	46.06	T19	9.78	T19	1.26
T19	46.51	T19	44.19	T19	2.33	T19	1.00
T19	48.96	T19	46.53	T19	2.43	T19	0.00
T20	25.31	T20	11.88	T20	13.44	T20	1.56
T20	41.41	T20	18.40	T20	23.01	T20	18.10
T20	40.85	T20	28.66	T20	12.20	T20	0.00
T21	56.51	T21	9.52	T21	46.98	T21	1.90
T22	46.48	T22	38.23	T22	8.26	T22	0.31
T22	92.55	T22	40.06	T22	52.48	T22	0.00
T22	47.37	T22	46.13	T22	1.24	T22	0.00
T23	80.94	T23	13.78	T23	67.16	T23	0.00
T24	56.97	T24	52.73	T24	4.24	T24	0.30
T25	67.81	T25	64.06	T25	3.75	T25	0.31
T26	64.98	T26	58.36	T26	6.62	T26	4.42
T27	76.87	T27	49.46	T27	27.41	T27	3.21
T28	67.62	T28	13.02	T28	54.60	T28	3.81
T28	66.04	T28	22.96	T28	43.08	T28	0.00
T28	47.34	T28	19.44	T28	27.90	T28	2.82
T29	70.91	T29	14.85	T29	56.06	T29	1.21
T30	44.92	T30	12.71	T30	32.20	T30	4.24
T30	46.99	T30	22.06	T30	24.93	T30	0.86
T30	86.13	T30	4.19	T30	81.94	T30	0.32
T31	82.12	T31	23.51	T31	58.61	T31	0.33
T32	72.82	T32	10.36	T32	62.46	T32	0.32
T33	75.57	T33	12.38	T33	63.19	T33	0.98
T33	65.73	T33	8.10	T33	57.63	T33	1.87
T33	68.50	T33	11.56	T33	56.94	T33	2.31

Metric 34		Metric 35		Metric 36	
StationID	% Scrapers	StationID	Scrapers / (Scrapers+Filterers)	StationID	Gatherer Taxa
R01	7.86	R01	17.89	R01	16.00
R02	4.09	R02	7.19	R02	12.00
R03	5.38	R03	35.71	R03	10.00
R04	4.64	R04	9.09	R04	8.00
R05	0.86	R05	75.00	R05	3.00
R06	22.08	R06	23.58	R06	5.00
R07	16.84	R07	52.08	R07	8.00
R08	19.9	R08	44.83	R08	11.00
R09	5.7	R09	64.29	R09	12.00
R10	11.9	R10	13.61	R10	6.00
R11	7.5	R11	24.49	R11	13.00
R12	31.2	R12	41.39	R12	8.00
R13	15.4	R13	76.06	R13	14.00
T04	1.38	T04	13.79	T04	17.00
T05	7.40	T05	54.76	T05	12.00
T06	1.53	T06	33.33	T06	13.00
T07	11.15	T07	34.34	T07	11.00
T08	5.63	T08	20.45	T08	15.00
T08	4.47	T08	16.84	T08	13.00
T09	11.56	T09	65.15	T09	15.00
T10	1.45	T10	66.67	T10	10.00
T11	22.60	T11	61.34	T11	9.00
T11	9.49	T11	56.00	T11	13.00
T12	36.96	T12	67.55	T12	11.00
T13	7.19	T13	18.75	T13	13.00
T13	2.77	T13	22.22	T13	15.00
T14	3.08	T14	31.03	T14	13.00
T15	5.8	T15	96.77	T15	12.00
T17	18.2	T17	88.33	T17	9.00
T18	22.4	T18	73.53	T18	8.00
T19	8.2	T19	45.61	T19	12.00
T19	13.0	T19	84.78	T19	10.00
T19	10.1	T19	80.56	T19	7.00
T20	71.9	T20	84.25	T20	6.00
T20	35.0	T20	60.32	T20	7.00
T20	54.0	T20	81.57	T20	7.00
T21	34.6	T21	42.41	T21	10.00
T22	46.5	T22	84.92	T22	8.00
T22	2.5	T22	4.52	T22	7.00
T22	47.7	T22	97.47	T22	6.00
T23	16.4	T23	19.65	T23	10.00
T24	19.7	T24	82.28	T24	11.00
T25	16.88	T25	81.82	T25	15.00
T26	22.7	T26	77.42	T26	13.00
T27	9.6	T27	26.01	T27	14.00
T28	21.3	T28	28.03	T28	12.00
T28	25.5	T28	37.16	T28	11.00
T28	46.4	T28	62.45	T28	11.00
T29	24.5	T29	30.45	T29	7.00
T30	46.0	T30	58.84	T30	7.00
T30	38.1	T30	60.45	T30	8.00
T30	12.3	T30	13.01	T30	7.00
T31	15.2	T31	20.63	T31	9.00
T32	20.1	T32	24.31	T32	9.00
T33	11.1	T33	14.91	T33	9.00
T33	19.6	T33	25.40	T33	7.00
T33	20.2	T33	26.22	T33	6.00

Metric 37	
StationID	Filterer Taxa
R01	6.00
R02	7.00
R03	6.00
R04	9.00
R05	1.00
R06	8.00
R07	4.00
R08	7.00
R09	4.00
R10	11.00
R11	9.00
R12	10.00
R13	6.00
T04	3.00
T05	5.00
T06	6.00
T07	2.00
T08	5.00
T08	3.00
T09	8.00
T10	1.00
T11	6.00
T11	7.00
T12	7.00
T13	4.00
T13	2.00
T14	4.00
T15	2.00
T17	1.00
T18	4.00
T19	4.00
T19	2.00
T19	3.00
T20	6.00
T20	6.00
T20	4.00
T21	8.00
T22	6.00
T22	3.00
T22	3.00
T23	10.00
T24	4.00
T25	5.00
T26	4.00
T27	10.00
T28	8.00
T28	8.00
T28	7.00
T29	4.00
T30	9.00
T30	8.00
T30	5.00
T31	9.00
T32	10.00
T33	8.00
T33	11.00
T33	9.00

Metric 38	
StationID	Shredder Taxa
R01	2
R02	3
R03	1
R04	3
R05	0
R06	2
R07	2
R08	3
R09	2
R10	1
R11	2
R12	1
R13	1
T04	2
T05	3
T06	3
T07	1
T08	3
T08	2
T09	3
T10	1
T11	2
T11	2
T12	3
T13	2
T13	1
T14	3
T15	2
T17	0
T18	1
T19	1
T19	1
T19	0
T20	1
T20	1
T20	0
T21	2
T22	1
T22	0
T22	0
T23	0
T24	1
T25	1
T26	3
T27	1
T28	2
T28	0
T28	2
T29	3
T30	1
T30	2
T30	1
T31	1
T32	1
T33	1
T33	1
T33	2

Metric 39	
StationID	Scraper Taxa
R01	3
R02	2
R03	3
R04	2
R05	1
R06	3
R07	3
R08	5
R09	7
R10	3
R11	2
R12	5
R13	4
T04	3
T05	2
T06	4
T07	6
T08	3
T08	3
T09	4
T10	1
T11	5
T11	4
T12	6
T13	2
T13	2
T14	4
T15	7
T17	3
T18	4
T19	5
T19	4
T19	3
T20	5
T20	4
T20	5
T21	4
T22	5
T22	3
T22	4
T23	4
T24	3
T25	3
T26	7
T27	5
T28	7
T28	6
T28	6
T29	3
T30	4
T30	5
T30	3
T31	4
T32	5
T33	5
T33	4
T33	3

Metric 40			Metric 41	
StationID	**% Clingers**		StationID	**Clinger Taxa**
R01	8.93		R01	4
R02	9.67		R02	6
R03	10.39		R03	5
R04	24.15		R04	4
R05	1.14		R05	2
R06	42.75		R06	5
R07	27.27		R07	6
R08	11.35		R08	5
R09	4.14		R09	5
R10	39.47		R10	7
R11	12.77		R11	9
R12	29.94		R12	7
R13	22.00		R13	11
T04	3.11		T04	2
T05	14.47		T05	7
T06	13.35		T06	5
T07	17.87		T07	4
T08	9.75		T08	3
T08	25.31		T08	7
T09	7.14		T09	7
T10	0.72		T10	1
T11	10.17		T11	5
T11	34.67		T11	6
T12	37.09		T12	9
T13	34.25		T13	7
T13	28.72		T13	1
T14	45.23		T14	4
T15	60.31		T15	3
T17	2.75		T17	3
T18	3.88		T18	3
T19	24.61		T19	4
T19	32.89		T19	3
T19	34.72		T19	4
T20	76.56		T20	6
T20	46.01		T20	5
T20	55.49		T20	6
T21	48.57		T21	6
T22	38.53		T22	8
T22	27.02		T22	3
T22	53.87		T22	4
T23	46.92		T23	8
T24	0.91		T24	2
T25	12.19		T25	3
T26	13.25		T26	6
T27	42.18		T27	7
T28	30.48		T28	10
T28	28.93		T28	9
T28	47.02		T28	6
T29	29.70		T29	4
T30	68.64		T30	9
T30	54.15		T30	8
T30	77.10		T30	6
T31	45.03		T31	8
T32	31.39		T32	8
T33	47.88		T33	10
T33	33.33		T33	7
T33	44.51		T33	8

Appendix MM.
TSS Loadings and Reductions by Site

					FLUX Modeled				Reduction Needed
					Loading		Max. Allowed 10%MOS		Monthly
Site	Stream	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
R01	BSR nr Brookings	1999	7	25.501	201492.8	5138268	158000	3662871	29
R01	BSR nr Brookings	1999	8	13.072	162634.8	2125962	158000	1877615	12
R01	BSR nr Brookings	1999	9	13.338	184598.6	2462176	158000	1915822	22
R01	BSR nr Brookings	1999	10	8.126	84757.79	688742	158000	1167189	-69
R01	BSR nr Brookings	2000	3	10.272	138597	1423668	158000	1475433	-4
R01	BSR nr Brookings	2000	4	8.324	84757.8	705524	158000	1195629	-69
R01	BSR nr Brookings	2000	5	16.422	186304.9	3059499	158000	2358796	23
R01	BSR nr Brookings	2000	6	14.754	177157.2	2613777	158000	2119211	19
R01	BSR nr Brookings	2000	7	9.031	134117.8	1211218	158000	1297180	-7
R01	BSR nr Brookings	2000	8	3.114	84757.78	263936	158000	447284	-69
R01	BSR nr Brookings	2000	9	1.42	84757.77	120356	158000	203964	-69
R01	BSR nr Brookings	2000	10	1.756	84757.77	148835	158000	252225	-69
Total				125		19961961		17973218	10
R02	BSR @ Sinai Rd	1999	7	27.227	177108.6	4822136	158000	3910787	19
R02	BSR @ Sinai Rd	1999	8	13.957	144667.3	2019122	158000	2004733	1
R02	BSR @ Sinai Rd	1999	9	14.241	163004.2	2321343	158000	2045525	12
R02	BSR @ Sinai Rd	1999	10	8.676	79650.25	691046	158000	1246189	-80
R02	BSR @ Sinai Rd	2000	3	10.968	124598.9	1366601	158000	1575404	-15
R02	BSR @ Sinai Rd	2000	4	8.888	79650.24	707931	158000	1276640	-80
R02	BSR @ Sinai Rd	2000	5	17.534	164428.7	2883093	158000	2518520	13
R02	BSR @ Sinai Rd	2000	6	15.753	156791.5	2469936	158000	2262704	8
R02	BSR @ Sinai Rd	2000	7	9.642	120859.4	1165326	158000	1384942	-19
R02	BSR @ Sinai Rd	2000	8	3.325	79650.25	264837	158000	477591	-80
R02	BSR @ Sinai Rd	2000	9	1.516	79650.22	120750	158000	217753	-80
R02	BSR @ Sinai Rd	2000	10	1.875	79650.23	149344	158000	269318	-80
Total				133.602		18981464		19190105	-1
R03	BSR @ Hwy 77	1999	7	29.793	210730.9	6278306	158000	4279358	32
R03	BSR @ Hwy 77	1999	8	15.272	174949.5	2671829	158000	2193615	18
R03	BSR @ Hwy 77	1999	9	15.583	195174.3	3041401	158000	2238285	26
R03	BSR @ Hwy 77	1999	10	9.494	103238.3	980144	158000	1363684	-39
R03	BSR @ Hwy 77	2000	3	12.002	152814.9	1834084	158000	1723924	6
R03	BSR @ Hwy 77	2000	4	9.725	103238.3	1003992	158000	1396864	-39
R03	BSR @ Hwy 77	2000	5	19.186	196745.5	3774759	158000	2755807	27
R03	BSR @ Hwy 77	2000	6	17.237	188322.1	3246108	158000	2475860	24
R03	BSR @ Hwy 77	2000	7	10.551	148690.3	1568831	158000	1515507	3
R03	BSR @ Hwy 77	2000	8	3.638	103238.3	375581	158000	522549	-39
R03	BSR @ Hwy 77	2000	9	1.659	103238.3	171272	158000	238293	-39
R03	BSR @ Hwy 77	2000	10	2.052	103238.3	211845	158000	294742	-39
Total				146		25158154		20998487	17
R04	BSR @ Brookings l	1999	7	31.16	182619.9	5690436	158000	4475709	21
R04	BSR @ Brookings l	1999	8	15.973	148547.1	2372743	158000	2294304	3
R04	BSR @ Brookings l	1999	9	16.298	167806.1	2734904	158000	2340985	14
R04	BSR @ Brookings l	1999	10	9.929	80260.38	796905	158000	1426165	-79
R04	BSR @ Brookings l	2000	3	12.552	127469.5	1599997	158000	1802924	-13
R04	BSR @ Brookings l	2000	4	10.171	80260.37	816328	158000	1460925	-79
R04	BSR @ Brookings l	2000	5	20.066	169302.3	3397220	158000	2882207	15
R04	BSR @ Brookings l	2000	6	18.028	161281	2907574	158000	2589476	11
R04	BSR @ Brookings l	2000	7	11.035	123541.9	1363285	158000	1585027	-16
R04	BSR @ Brookings l	2000	8	3.805	80260.37	305391	158000	546536	-79
R04	BSR @ Brookings l	2000	9	1.735	80260.38	139252	158000	249209	-79
R04	BSR @ Brookings l	2000	10	2.146	80260.38	172239	158000	308244	-79
Total				153		22296273		21961713	2

R05	BSR @ Flandreau	1999	7	32.223	175332.6	5649742	158000	4628395	18
R05	BSR @ Flandreau	1999	8	16.518	145665.5	2406103	158000	2372585	1
R05	BSR @ Flandreau	1999	9	16.854	162434.3	2737668	158000	2420847	12
R05	BSR @ Flandreau	1999	10	10.268	86208.59	885190	158000	1474858	-67
R05	BSR @ Flandreau	2000	3	12.98	127313.4	1652528	158000	1864400	-13
R05	BSR @ Flandreau	2000	4	10.518	86208.61	906742	158000	1510767	-67
R05	BSR @ Flandreau	2000	5	20.751	163737	3397706	158000	2980598	12
R05	BSR @ Flandreau	2000	6	18.643	154696.6	2884009	158000	2677813	7
R05	BSR @ Flandreau	2000	7	11.412	120534.2	1375536	158000	1639178	-19
R05	BSR @ Flandreau	2000	8	3.935	86208.6	339231	158000	565209	-67
R05	BSR @ Flandreau	2000	9	1.794	86208.59	154658	158000	257684	-67
R05	BSR @ Flandreau	2000	10	2.113	86208.63	182159	158000	303504	-67
Total				158		22571272		22695838	-1
R06	BSR @ Egan	1999	7	40.807	175007.5	7141531	158000	5861369	18
R06	BSR @ Egan	1999	8	18.345	131385.6	2410269	158000	2635009	-9
R06	BSR @ Egan	1999	9	17.683	123398.7	2182059	158000	2539922	-16
R06	BSR @ Egan	1999	10	10.397	59858.41	622348	158000	1493387	-140
R06	BSR @ Egan	2000	3	15.636	93020.16	1454463	158000	2245898	-54
R06	BSR @ Egan	2000	4	12.506	59858.4	748589	158000	1796316	-140
R06	BSR @ Egan	2000	5	29.039	158511	4603001	158000	4171056	9
R06	BSR @ Egan	2000	6	24.735	157257	3889752	158000	3552845	9
R06	BSR @ Egan	2000	7	13.509	98786.71	1334510	158000	1940384	-45
R06	BSR @ Egan	2000	8	5.659	59858.39	338739	158000	812838	-140
R06	BSR @ Egan	2000	9	2.81	59858.39	168202	158000	403618	-140
R06	BSR @ Egan	2000	10	2.593	59858.4	155213	158000	372449	-140
Total				194		25048675		27825093	-11
R07	BSR @ Trent	1999	7	42.849	190710.9	8171771	158000	6154675	25
R07	BSR @ Trent	1999	8	19.263	142010.6	2735550	158000	2766867	-1
R07	BSR @ Trent	1999	9	18.567	133093.7	2471151	158000	2666896	-8
R07	BSR @ Trent	1999	10	10.917	62156.11	678558	158000	1568078	-131
R07	BSR @ Trent	2000	3	16.418	99178.53	1628313	158000	2358222	-45
R07	BSR @ Trent	2000	4	13.131	62156.11	816172	158000	1886089	-131
R07	BSR @ Trent	2000	5	30.492	172293.9	5253586	158000	4379760	17
R07	BSR @ Trent	2000	6	25.973	170894	4438630	158000	3730667	16
R07	BSR @ Trent	2000	7	14.185	105616.4	1498169	158000	2037482	-36
R07	BSR @ Trent	2000	8	5.942	62156.1	369332	158000	853487	-131
R07	BSR @ Trent	2000	9	2.951	62156.09	183423	158000	423871	-131
R07	BSR @ Trent	2000	10	2.723	62156.1	169251	158000	391122	-131
Total				203		28413905		29217216	-3

					FLUX Modeled				Reduction Needed
					Loading		Max. Allowed 10%MOS		Monthly
Site	Stream	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
R08	BSR @ USGS Dell Rapi	2000	7	14.468	106745.7	1544397	158000	2078131	-35
R08	BSR @ USGS Dell Rapi	2000	8	6.061	106745.8	646986	158000	870580	-35
R08	BSR @ USGS Dell Rapi	2000	9	3.01	106745.8	321305	158000	432345	-35
R08	BSR @ USGS Dell Rapi	2000	10	2.909	106745.8	310524	158000	417838	-35
R08	BSR @ USGS Dell Rapi	2001	5	220.556	123493.4	27237210	158000	31679862	-16
R08	BSR @ USGS Dell Rapi	2001	6	148.84	123168.5	18332400	158000	21378836	-17
R08	BSR @ USGS Dell Rapi	2001	7	68.863	108173.9	7449179	158000	9891231	-33
R08	BSR @ USGS Dell Rapi	2001	8	41.42	106745.7	4421407	158000	5949418	-35
R08	BSR @ USGS Dell Rapi	2001	9	24.61	106745.7	2627012	158000	3534891	-35
R08	BSR @ USGS Dell Rapi	2001	10	17.656	106745.7	1884702	158000	2536044	-35
Total				548.393		64775121	158000	78769176	-22
R09	BSR @ Hwy 38A	2000	7	14.583	115861.4	1689607	158000	2094649	-24
R09	BSR @ Hwy 38A	2000	8	6.109	115861.4	707797	158000	877475	-24
R09	BSR @ Hwy 38A	2000	9	3.034	115861.4	351523	158000	435793	-24
R09	BSR @ Hwy 38A	2000	10	2.932	115861.4	339706	158000	421142	-24
R09	BSR @ Hwy 38A	2001	5	222.315	182002.5	40461886	158000	31932518	21
R09	BSR @ Hwy 38A	2001	6	150.027	180719.5	27112804	158000	21549333	21
R09	BSR @ Hwy 38A	2001	7	69.412	121501.6	8433669	158000	9970087	-18
R09	BSR @ Hwy 38A	2001	8	41.75	115861.4	4837213	158000	5996818	-24
R09	BSR @ Hwy 38A	2001	9	24.806	115861.4	2874058	158000	3563044	-24
R09	BSR @ Hwy 38A	2001	10	17.797	115861.4	2061985	158000	2556296	-24
Total				552.765		88870249		79397155	11
R10	BSR @ Western Ave	2000	7	3.607	104502.1	376939	158000	518096	-37
R10	BSR @ Western Ave	2000	8	2.358	159859.1	376948	158000	338695	10
R10	BSR @ Western Ave	2000	9	0.903	403833.7	364662	158000	129704	64
R10	BSR @ Western Ave	2000	10	1.681	224255.1	376973	158000	241453	36
R10	BSR @ Western Ave	2001	5	65.53	217488.7	14252035	158000	9412491	34
R10	BSR @ Western Ave	2001	6	34.154	403819.9	13792065	158000	4905756	64
R10	BSR @ Western Ave	2001	7	13.932	412568.3	5747902	158000	2001142	65
R10	BSR @ Western Ave	2001	8	5.715	65946.8	376886	158000	820882	-118
R10	BSR @ Western Ave	2001	9	3.943	92496.05	364712	158000	566358	-55
R10	BSR @ Western Ave	2001	10	3.429	106379.8	364776	158000	492529	-35
Total				135.252		36393897	158000	19427105	47
R11	BSR @ USGS N. Cliff A\	2000	7	16.881	170949.8	2885804	158000	2424725	16
R11	BSR @ USGS N. Cliff A\	2000	8	8.601	170949.8	1470339	158000	1235416	16
R11	BSR @ USGS N. Cliff A\	2000	9	3.333	170949.7	569775	158000	478740	16
R11	BSR @ USGS N. Cliff A\	2000	10	3.888	170949.8	664653	158000	558458	16
R11	BSR @ USGS N. Cliff A\	2001	5	261.296	190317.6	49729228	158000	37531607	25
R11	BSR @ USGS N. Cliff A\	2001	6	164.451	188758.7	31041557	158000	23621144	24
R11	BSR @ USGS N. Cliff A\	2001	7	88.029	176510.8	15538069	158000	12644165	19
R11	BSR @ USGS N. Cliff A\	2001	8	51.559	170949.7	8813996	158000	7405747	16
R11	BSR @ USGS N. Cliff A\	2001	9	28.633	170949.7	4894803	158000	4112740	16
R11	BSR @ USGS N. Cliff A\	2001	10	18.554	170949.8	3171803	158000	2665029	16
Total				645.225		118780026		92677773	22

R12	BSR @ Brandon	2000	7	17.103	126025.5	2155414	158000	2456613	-14
R12	BSR @ Brandon	2000	8	8.714	247354.2	2155444	158000	1251647	42
R12	BSR @ Brandon	2000	9	3.376	617770.1	2085592	158000	484916	77
R12	BSR @ Brandon	2000	10	3.939	547167.9	2155294	158000	565784	74
R12	BSR @ Brandon	2001	5	266.149	154022.3	40992881	158000	38228675	7
R12	BSR @ Brandon	2001	6	167.534	236790.3	39670426	158000	24063975	39
R12	BSR @ Brandon	2001	7	89.027	333803.4	29717515	158000	12787515	57
R12	BSR @ Brandon	2001	8	52.912	206476.2	10925069	158000	7600087	30
R12	BSR @ Brandon	2001	9	28.972	71994.79	2085833	158000	4161433	-100
R12	BSR @ Brandon	2001	10	19.297	108093.1	2085873	158000	2771751	-33
Total				657.02		134029342	158000	94372395	30
R13	BSR nr Gitchie Manitou	2000	7	6.465	226760.8	1466009	158000	928609	37
R13	BSR nr Gitchie Manitou	2000	8	12.118	288472.3	3495707	158000	1740585	50
R13	BSR nr Gitchie Manitou	2000	9	4.839	699121.7	3383050	158000	695056	79
R13	BSR nr Gitchie Manitou	2000	10	5.854	597116.3	3495519	158000	840847	76
R13	BSR nr Gitchie Manitou	2001	5	323.849	423809.8	137250380	158000	46516493	66
R13	BSR nr Gitchie Manitou	2001	6	217.13	611719.6	132822677	158000	31187764	77
R13	BSR nr Gitchie Manitou	2001	7	127.977	971318.3	124306402	158000	18382151	85
R13	BSR nr Gitchie Manitou	2001	8	82.362	356762	29383632	158000	11830178	60
R13	BSR nr Gitchie Manitou	2001	9	55.683	60752.97	3382908	158000	7998104	-136
R13	BSR nr Gitchie Manitou	2001	10	53.707	304000.8	16326971	158000	7714278	53
Total				889.984		455313254	158000	127834065	72

					FLUX Modeled				Reduction Needed
					Loading		Max. Allowed 10%MOS		Monthly
Site	Stream	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
T01	North Deer Creek	1999	8	0.136	15387.16	2093	263000	35768	-1609
T01	North Deer Creek	1999	9	0.252	15595.85	3930	263000	66276	-1586
T01	North Deer Creek	1999	10	0.154	21655.85	3335	263000	40502	-1114
T01	North Deer Creek	2000	4	0.153	16874.32	2582	263000	40239	-1459
T01	North Deer Creek	2000	5	0.446	13989.07	7526	263000	117298	-1459
T01	North Deer Creek	2000	6	0.649	9831.91	9079	263000	170687	-1780
T01	North Deer Creek	2000	7	0.306	16040.32	4908	263000	80478	-1540
T01	North Deer Creek	2000	8	0.038	69521.93	2642	263000	9994	-278
T01	North Deer Creek	2000	9	0.178	27055.05	4816	263000	46814	-872
T01	North Deer Creek	2000	10	0.923	9714.24	8966	263000	242749	-2607
Total				3		49877		850805	-1606
T02	North Deer Creek	1999	7	0.18	8588	1546	263000	47340	-2962
T02	North Deer Creek	1999	8	0		0	263000	0	0
T02	North Deer Creek	1999	9	0.018	8588	155	263000	4734	-2962
T02	North Deer Creek	1999	10	0		0	263000	0	0
T02	North Deer Creek	2000	3	0.474	46715	22143	263000	124662	-463
T02	North Deer Creek	2000	4	0.615	47084	28957	263000	161745	-459
T02	North Deer Creek	2000	5	1.973	81103	160016	263000	518899	-224
T02	North Deer Creek	2000	6	1.261	74716	94217	263000	331643	-252
T02	North Deer Creek	2000	7	0.771	67566	52093	263000	202773	-289
T02	North Deer Creek	2000	8	0.003	8588	26	263000	804	-3022
Total				5		359152		1392600	-288

T03	Six Mile Creek	1999	7	0.093	35527.1	3316	263000	24459	-638
T03	Six Mile Creek	2000	3	0.032	35564.5	1138	263000	8416	-640
T03	Six Mile Creek	2000	4	0.164	35979.7	5901	263000	43132	-631
T03	Six Mile Creek	2000	5	0.376	35125.8	13207	263000	98888	-649
T03	Six Mile Creek	2000	6	0.349	35232.5	12296	263000	91787	-646
T03	Six Mile Creek	2000	7	0.423	35231.3	14903	263000	111249	-646
T03	Six Mile Creek	2000	8	0.032	36428.0	1166	263000	8416	-622
T03	Six Mile Creek	2000	9	0	0.0	0	263000	0	0
T03	Six Mile Creek	2000	10	0	0.0	0	263000	0	0
Total				1		51927		386347	-644

T04	Six Mile Creek	1999	7	0.375	65348.0	24505	263000	98625	-302
T04	Six Mile Creek	1999	8	0.294	43942.7	12919	263000	77322	-499
T04	Six Mile Creek	1999	9	0.304	43942.7	13359	263000	79952	-499
T04	Six Mile Creek	1999	10	0.384	43942.7	16874	263000	100992	-499
T04	Six Mile Creek	2000	3	0.364	64177.9	23361	263000	95732	-310
T04	Six Mile Creek	2000	4	0.509	67783.1	34502	263000	133867	-288
T04	Six Mile Creek	2000	5	1.458	101599.1	148131	263000	383454	-159
T04	Six Mile Creek	2000	6	0.845	89520.1	75645	263000	222235	-194
T04	Six Mile Creek	2000	7	0.731	90304.4	66013	263000	192253	-191
T04	Six Mile Creek	2000	8	0.285	43942.7	12524	263000	74955	-499
T04	Six Mile Creek	2000	9	0.145	43942.7	6372	263000	38135	-499
T04	Six Mile Creek	2000	10	0.231	43942.7	10151	263000	60753	-499
Total				6		444354		1558275	-251

T05	Six Mile Creek	1999	7	0.035	63615.1	19614	263000	9205	53
T05	Six Mile Creek	1999	8	0.031	54817.8	1715	263000	8153	-375
T05	Six Mile Creek	1999	9	0.064	25341.7	1609	263000	16832	-946
T05	Six Mile Creek	1999	10	0.112	25341.7	2836	263000	29456	-939
T05	Six Mile Creek	2000	3	0.406	81585.2	33114	263000	106778	-222
T05	Six Mile Creek	2000	4	0.542	82140.9	44531	263000	142546	-220
T05	Six Mile Creek	2000	5	1.686	86106.9	145190	263000	443418	-205
T05	Six Mile Creek	2000	6	0.897	84833.6	76091	263000	235911	-210
T05	Six Mile Creek	2000	7	0.626	74479.3	46636	263000	164638	-253
T05	Six Mile Creek	2000	8	0.034	59913.1	2027	263000	8942	-341
T05	Six Mile Creek	2000	9	0	0.0	0	263000	0	0
T05	Six Mile Creek	2000	10	0	0.0	0	263000	0	0
Total				4		373364		1165879	-212

T06	Deer Creek	1999	8	0.008	14433.35	113	263000	1913	-1596
T06	Deer Creek	1999	9	0.049	14433.35	709	263000	11715	-1552
T06	Deer Creek	1999	10	0.111	14433.35	1597	263000	26539	-1562
T06	Deer Creek	2000	3	0.169	36547.13	6194	263000	40406	-552
T06	Deer Creek	2000	4	0.336	81166.15	27244	263000	80335	-195
T06	Deer Creek	2000	5	1.425	128350.2	182940	263000	340705	-86
T06	Deer Creek	2000	6	1.28	134096.5	171680	263000	306036	-78
T06	Deer Creek	2000	7	0.813	127831.1	103967	263000	194381	-87
T06	Deer Creek	2000	8	0.097	14433.35	1406	263000	23192	-1549
Total				4.288		495850		1025222	-107

T07	Medary Creek	1999	7	0.323	26198.41	8453	263000	77226	-814
T07	Medary Creek	1999	8	0.109	21203.43	2311	263000	26061	-1028
T07	Medary Creek	1999	9	0.121	19948.04	2418	263000	28930	-1096
T07	Medary Creek	1999	10	0.149	18258.31	2722	263000	35625	-1209
T07	Medary Creek	2000	3	0.263	23009.94	6049	263000	62881	-940
T07	Medary Creek	2000	4	0.378	23371.46	8832	263000	90376	-923
T07	Medary Creek	2000	5	1.573	28651.21	45064	263000	376090	-735
T07	Medary Creek	2000	6	1.115	28718.19	32027	263000	266586	-732
T07	Medary Creek	2000	7	0.174	18258.31	3178	263000	41602	-1209
T07	Medary Creek	2000	8	0.077	18258.31	1397	263000	18410	-1218
T07	Medary Creek	2000	9	0.025	18258.31	454	263000	5977	-1218
T07	Medary Creek	2000	10	0.057	18258.31	1040	263000	13628	-1210
Total				4		113946		1043393	-816

T08	Medary Creek	1999	7	0.461	32653.8	15051	263000	110221	-632
T08	Medary Creek	1999	8	0.131	21580.64	2820	263000	31321	-1011
T08	Medary Creek	1999	9	0.221	25462.93	5619	263000	52839	-840
T08	Medary Creek	1999	10	0.282	21580.65	6095	263000	67424	-1006
T08	Medary Creek	2000	3	0.618	37183.23	22987	263000	147758	-543
T08	Medary Creek	2000	4	0.831	34618.78	28766	263000	198685	-591
T08	Medary Creek	2000	5	2.012	36192.89	72816	263000	481051	-561
T08	Medary Creek	2000	6	2.375	37183.23	88326	263000	567841	-543
T08	Medary Creek	2000	7	0.663	29137.8	19304	263000	158517	-721
T08	Medary Creek	2000	8	0.24	21580.65	5183	263000	57382	-1007
T08	Medary Creek	2000	9	0.03	21580.64	655	263000	7173	-995
T08	Medary Creek	2000	10	0.087	28394	2465	263000	20801	-744
Total				8		270088		1901012	-604
T09	Medary Creek	1999	8	0.235	21118.61	4971	263000	56186	-1030
T09	Medary Creek	1999	9	0.627	21118.61	13251	263000	149910	-1031
T09	Medary Creek	1999	10	0.976	48093	46937	263000	233353	-397
T09	Medary Creek	1999	11	0.3	91364.01	27431	263000	71727	-161
T09	Medary Creek	2000	3	0.844	84093.88	70988	263000	201793	-184
T09	Medary Creek	2000	4	1.518	85303.92	129511	263000	362940	-180
T09	Medary Creek	2000	5	3.421	88794.94	303731	263000	817930	-169
T09	Medary Creek	2000	6	3.73	91364.01	340754	263000	891809	-162
T09	Medary Creek	2000	7	1.212	44264.63	53668	263000	289778	-440
T09	Medary Creek	2000	8	0.432	21118.61	9130	263000	103287	-1031
T09	Medary Creek	2000	9	0.205	21118.61	4333	263000	49014	-1031
T09	Medary Creek	2000	10	0.146	21118.61	3198	263000	34907	-992
Total				14		1007902		3262635	-224
T10	Lake Cambell Outlet	2000	3	0.003	63766.33	163	263000	717	-341
T10	Lake Cambell Outlet	2000	4	0.04	45394.47	1808	263000	9564	-429
T10	Lake Cambell Outlet	2000	5	1.668	28380.71	47346	263000	398804	-742
T10	Lake Cambell Outlet	2000	6	1.034	28298.43	29256	263000	247220	-745
T10	Lake Cambell Outlet	2000	7	0.092	32976.37	3048	263000	21996	-622
T10	Lake Cambell Outlet	2000	8	0.088	30859.93	2709	263000	21040	-677
T10	Lake Cambell Outlet	2000	9	0.066	32815.85	2164	263000	15780	-629
T10	Lake Cambell Outlet	2000	10	0.069	29783.97	2056	263000	16497	-702
T10	Lake Cambell Outlet	2000	11	0.002	63766.32	145	263000	478	-230
Total				3		88694		732096	-725
T11	Spring Creek	1999	7	0.393	23036.91	9055	263000	93963	-938
T11	Spring Creek	1999	8	0.437	15900.36	6943	263000	104483	-1405
T11	Spring Creek	1999	9	0.374	16087.78	6020	263000	89420	-1385
T11	Spring Creek	1999	10	0.415	13486.94	5594	263000	99223	-1674
T11	Spring Creek	2000	3	0.463	23386.81	10829	263000	110699	-922
T11	Spring Creek	2000	4	0.586	22022.51	12906	263000	140107	-986
T11	Spring Creek	2000	5	1.338	41612.92	55678	263000	319904	-475
T11	Spring Creek	2000	6	1.282	45911.84	58857	263000	306515	-421
T11	Spring Creek	2000	7	0.723	25977.37	18788	263000	172863	-820
T11	Spring Creek	2000	8	0.567	16609.26	9422	263000	135565	-1339
T11	Spring Creek	2000	9	0.488	13486.94	6587	263000	116676	-1671
T11	Spring Creek	2000	10	0.605	21921.61	13265	263000	144650	-990
Total				8		213944		1834066	-757

Site	Stream	Year	Month	Q (hm3)	FLUX Modeled Loading Conc (ppb)	Loading Mass (kg)	Max. Allowed 10%MOS Conc (ppb)	Max. Allowed 10%MOS Mass (kg)	Reduction Needed Monthly Ave. (%)
T12	Flandreau Creek	1999	8	0.154	83501.63	12857	263000	36820	-186
T12	Flandreau Creek	1999	9	0.66	90645.06	59804	263000	157800	-164
T12	Flandreau Creek	1999	10	0.605	30300.71	18333	263000	144650	-689
T12	Flandreau Creek	2000	3	0.278	134256.6	37335	263000	66467	-78
T12	Flandreau Creek	2000	4	1.127	198491.8	223654	263000	269455	-20
T12	Flandreau Creek	2000	5	2.843	229803.1	653351	263000	679735	-4
T12	Flandreau Creek	2000	6	2.238	218231.2	488446	263000	535085	-10
T12	Flandreau Creek	2000	7	0.43	48824.04	20982	263000	102809	-390
T12	Flandreau Creek	2000	8	0.188	30300.71	5700	263000	44949	-689
T12	Flandreau Creek	2000	9	0.002	30300.71	64	263000	478	-650
T12	Flandreau Creek	2000	10	0.139	30300.71	4201	263000	33234	-691
Total				9		1524725		2071484	-36
T13	Jack Moore Creek	1999	7	0.227	51250.52	11634	263000	54274	-367
T13	Jack Moore Creek	1999	8	0.015	13735.65	206	263000	3586	-1641
T13	Jack Moore Creek	1999	9	0.023	13735.65	316	263000	5499	-1641
T13	Jack Moore Creek	1999	10	0.092	13735.65	1264	263000	21996	-1641
T13	Jack Moore Creek	2000	3	0.085	39206.26	3333	263000	20323	-510
T13	Jack Moore Creek	2000	4	0.216	49290.98	10647	263000	51644	-385
T13	Jack Moore Creek	2000	5	1.145	55537.29	63590	263000	273759	-331
T13	Jack Moore Creek	2000	6	0.26	49846.38	12960	263000	62164	-380
T13	Jack Moore Creek	2000	7	0.006	13735.65	82	263000	1435	-1641
T13	Jack Moore Creek	2000	8	0.009	13735.65	124	263000	2152	-1641
T13	Jack Moore Creek	2000	9	0.004	13735.65	55	263000	956	-1641
T13	Jack Moore Creek	2000	10	0.01	13735.65	137	263000	2391	-1641
Total				2		104347		500178	-379
T14	Bachelor Creek	2000	4	0.14	133971	18756	263000	33473	-78
T14	Bachelor Creek	2000	5	1.877	130966	245823	263000	448774	-83
T14	Bachelor Creek	2000	6	0.555	106109	58890	263000	132695	-125
T14	Bachelor Creek	2000	7	0.193	43872	8467	263000	46145	-445
T14	Bachelor Creek	2000	8	0.051	5890	300	263000	12194	-3959
T14	Bachelor Creek	2000	9	0.015	5890	88	263000	3586	-3959
T14	Bachelor Creek	2000	10	0.029	5890	171	263000	6934	-3959
Total				3		332496		683800	-106

					FLUX Modeled				Reduction Needed
					Loading		Max. Allowed 10%MOS		Monthly
Site	Stream	Year	Month	Q (hm3)	Conc (ppb)	Mass (kg)	Conc (ppb)	Mass (kg)	Ave. (%)
T15	N. Buffalo Ck	2000	7	0.261	120690.00	31500	263000	62403	-98
T15	N. Buffalo Ck	2000	8	0.351	120690.00	42362	263000	83921	-98
T15	N. Buffalo Ck	2000	9	0.59	120690.00	71207	263000	141064	-98
T15	N. Buffalo Ck	2000	10	1.259	120690.00	151949	263000	301015	-98
T15	N. Buffalo Ck	2001	3	1.507	35606.16	53658	263000	360310	-571
T15	N. Buffalo Ck	2001	4	13.089	24677.00	322997	263000	3129461	-869
T15	N. Buffalo Ck	2001	5	3.837	41820.93	160467	263000	917392	-472
T15	N. Buffalo Ck	2001	6	2.523	53645.57	135348	263000	603226	-346
T15	N. Buffalo Ck	2001	7	0.203	120690.00	24500	263000	48535	-98
T15	N. Buffalo Ck	2001	8	0.066	120690.00	7966	263000	15780	-98
T15	N. Buffalo Ck	2001	9	0.093	120690.00	11224	263000	22235	-98
T15	N. Buffalo Ck	2001	10	0.106	120690.00	12793	263000	25344	-98
Total				23.885		1025971		5710686	-457
T16	Buffalo Ck	2000	7	0.211	132811.50	28023	263000	50448	-80
T16	Buffalo Ck	2000	8	0.18	201858.30	36334	263000	43036	-18
T16	Buffalo Ck	2000	9	0.254	138168.80	35095	263000	60729	-73
T16	Buffalo Ck	2000	10	0.342	99100.65	33892	263000	81769	-141
T16	Buffalo Ck	2001	3	2.654	194851.90	517137	263000	634547	-23
T16	Buffalo Ck	2001	4	13.935	92789.36	1293020	263000	3331732	-158
T16	Buffalo Ck	2001	5	4.195	178555.50	749040	263000	1002986	-34
T16	Buffalo Ck	2001	6	2.049	180799.10	370457	263000	489897	-32
T16	Buffalo Ck	2001	7	0.303	119512.60	36212	263000	72445	-100
T16	Buffalo Ck	2001	8	0.084	433674.50	36429	263000	20084	45
T16	Buffalo Ck	2001	9	0.035	998207.20	34937	263000	8368	76
T16	Buffalo Ck	2001	10	0.035	998207.20	34937	263000	8368	76
Total				24.277		3205515		5804410	-81
T17	Brant Lake Outlet	2000	7	1.736	18902.31	32814	263000	415062	-1165
T17	Brant Lake Outlet	2000	8	1.125	19489.25	21925	263000	268977	-1127
T17	Brant Lake Outlet	2000	9	1.018	19589.25	19942	263000	243395	-1121
T17	Brant Lake Outlet	2000	10	1.102	19560.48	21556	263000	263478	-1122
T17	Brant Lake Outlet	2001	3	0.554	18618.74	10315	263000	132456	-1184
T17	Brant Lake Outlet	2001	4	15.104	19812.14	299243	263000	3611229	-1107
T17	Brant Lake Outlet	2001	5	14.635	17887.42	261782	263000	3499095	-1237
T17	Brant Lake Outlet	2001	6	37.146	44103.37	1638264	263000	8881271	-442
T17	Brant Lake Outlet	2001	7	19.799	23348.91	462285	263000	4733761	-924
T17	Brant Lake Outlet	2001	8	10.631	16260.2	172862	263000	2541775	-1370
T17	Brant Lake Outlet	2001	9	10.285	16382.69	168496	263000	2459050	-1359
T17	Brant Lake Outlet	2001	10	10.243	17042.36	174565	263000	2449008	-1303
Total				123.378		3284049		29498558	-798
T18	Skunk Ck (upper)	2000	7	0.811	185015.7	150048	263000	193903	-29
T18	Skunk Ck (upper)	2000	8	0.397	403713.8	160274	263000	94919	41
T18	Skunk Ck (upper)	2000	9	0.345	450054.3	155269	263000	82486	47
T18	Skunk Ck (upper)	2000	10	0.334	464520.4	155150	263000	79856	49
T18	Skunk Ck (upper)	2001	3	5.042	109350.2	551344	263000	1205496	-119
T18	Skunk Ck (upper)	2001	4	37.29	47898.3	1786128	263000	8915700	-399
T18	Skunk Ck (upper)	2001	5	16.967	60717.79	1030199	263000	4056655	-294
T18	Skunk Ck (upper)	2001	6	8.504	107753.9	916339	263000	2033229	-122
T18	Skunk Ck (upper)	2001	7	2.277	70445.44	160404	263000	544410	-239
T18	Skunk Ck (upper)	2001	8	0.664	241530.5	160376	263000	158756	1
T18	Skunk Ck (upper)	2001	9	0.548	283467	155340	263000	131022	16
T18	Skunk Ck (upper)	2001	10	0.597	260013.3	155228	263000	142737	8
Total				73.776		5536098		17639171	-219

T19	Colton Ck	2000	7	0.186	354016.9	65847	263000	44471	32
T19	Colton Ck	2000	8	0.406	354016.8	143731	263000	97071	32
T19	Colton Ck	2000	9	0.423	354016.8	149749	263000	101135	32
T19	Colton Ck	2000	10	0.423	354016.8	149749	263000	101135	32
T19	Colton Ck	2001	3	5.086	200934.2	1021951	263000	1216016	-19
T19	Colton Ck	2001	4	8.002	200934.2	1607875	263000	1913205	-19
T19	Colton Ck	2001	5	2.974	231577.7	688712	263000	711056	-3
T19	Colton Ck	2001	6	2.371	249187.6	590824	263000	566885	4
T19	Colton Ck	2001	7	0.637	298018.3	189838	263000	152301	20
T19	Colton Ck	2001	8	0.08	354016.9	28321	263000	19127	32
T19	Colton Ck	2001	9	0.026	354016.8	9204	263000	6216	32
T19	Colton Ck	2001	10	0.041	354016.8	14515	263000	9803	32
Total				20.655		4660317		4938423	-6
T20	W. Branch Skunk Ck	2000	7	0.525	69339.83	36403	263000	125523	-245
T20	W. Branch Skunk Ck	2000	8	0.35	69339.82	24269	263000	83682	-245
T20	W. Branch Skunk Ck	2000	9	0.179	69339.85	12412	263000	42797	-245
T20	W. Branch Skunk Ck	2000	10	0.209	69339.84	14492	263000	49970	-245
T20	W. Branch Skunk Ck	2001	3	15.323	83163.59	1274316	263000	3663590	-187
T20	W. Branch Skunk Ck	2001	4	10.636	82698.15	879578	263000	2542971	-189
T20	W. Branch Skunk Ck	2001	5	2.84	76614.88	217586	263000	679018	-212
T20	W. Branch Skunk Ck	2001	6	2.412	77033.57	185805	263000	576687	-210
T20	W. Branch Skunk Ck	2001	7	0.983	73295.16	72049	263000	235026	-226
T20	W. Branch Skunk Ck	2001	8	0.376	69339.84	26072	263000	89898	-245
T20	W. Branch Skunk Ck	2001	9	0.308	69339.83	21357	263000	73640	-245
T20	W. Branch Skunk Ck	2001	10	0.334	69339.84	23160	263000	79856	-245
Total				34.475		2787498		8242659	-196
T21	Skunk Ck (middle)	2000	7	2.59	148010.7	383348	263000	619245	-62
T21	Skunk Ck (middle)	2000	8	2.249	182200.3	409768	263000	537715	-31
T21	Skunk Ck (middle)	2000	9	1.78	222761.8	396516	263000	425582	-7
T21	Skunk Ck (middle)	2000	10	1.78	222761.8	396516	263000	425582	-7
T21	Skunk Ck (middle)	2001	3	12.75	445844.2	5684514	263000	3048409	46
T21	Skunk Ck (middle)	2001	4	74.697	190258.4	14211732	263000	17859374	-26
T21	Skunk Ck (middle)	2001	5	33.933	392065.3	13303952	263000	8113072	39
T21	Skunk Ck (middle)	2001	6	17.661	309270.6	5462028	263000	4222585	23
T21	Skunk Ck (middle)	2001	7	6.498	133925.7	870249	263000	1553613	-79
T21	Skunk Ck (middle)	2001	8	2.318	176809.8	409845	263000	554213	-35
T21	Skunk Ck (middle)	2001	9	1.768	224237.2	396451	263000	422713	-7
T21	Skunk Ck (middle)	2001	10	1.709	231993.1	396476	263000	408606	-3
Total				159.733		42321395		38190708	10
T22	Willow Ck	2000	7	0.269	171876.4	46235	263000	64315	-39
T22	Willow Ck	2000	8	0.175	89143.66	15600	263000	41841	-168
T22	Willow Ck	2000	9	0.058	89143.66	5170	263000	13867	-168
T22	Willow Ck	2000	10	0.055	89143.68	4903	263000	13150	-168
T22	Willow Ck	2001	3	6.337	307340.9	1947619	263000	1515119	22
T22	Willow Ck	2001	4	6.314	300653	1898323	263000	1509620	20
T22	Willow Ck	2001	5	2.184	253868.6	554449	263000	522175	6
T22	Willow Ck	2001	6	1.75	257943.1	451400	263000	418409	7
T22	Willow Ck	2001	7	1.243	281146.4	349465	263000	297190	15
T22	Willow Ck	2001	8	0.1	89143.66	8914	263000	23909	-168
T22	Willow Ck	2001	9	0.058	89143.69	5170	263000	13867	-168
T22	Willow Ck	2001	10	0.06	89143.68	5309	263000	14345	-170
Total				18.603		5292558		4447808	16

					FLUX Modeled				Reduction Needed
					Loading		Max. Allowed 10%MOS		Monthly
Site	**Stream**	**Year**	**Month**	**Q (hm3)**	**Conc (ppb)**	**Mass (kg)**	**Conc (ppb)**	**Mass (kg)**	**Ave. (%)**
T23	Skunk Ck (lower)	2000	7	2.144	83635.98	179316	263000	512611	-186
T23	Skunk Ck (lower)	2000	8	1.745	83635.98	145945	263000	417214	-186
T23	Skunk Ck (lower)	2000	9	0.599	83635.98	50098	263000	143215	-186
T23	Skunk Ck (lower)	2000	10	1.387	83635.98	116003	263000	331619	-186
T23	Skunk Ck (lower)	2001	3	13.033	165613.8	2158445	263000	3116072	-44
T23	Skunk Ck (lower)	2001	4	101.328	176638.3	17898406	263000	24226604	-35
T23	Skunk Ck (lower)	2001	5	42.259	172157.3	7275195	263000	10103743	-39
T23	Skunk Ck (lower)	2001	6	20.167	140690.6	2837307	263000	4821746	-70
T23	Skunk Ck (lower)	2001	7	7.382	119633.3	883133	263000	1764969	-100
T23	Skunk Ck (lower)	2001	8	1.962	83635.98	164094	263000	469096	-186
T23	Skunk Ck (lower)	2001	9	1.293	83635.97	108141	263000	309145	-186
T23	Skunk Ck (lower)	2001	10	1.382	83635.98	115585	263000	330424	-186
Total				194.681		31931667		46546457	-46
T24	Silver Ck	2001	5	2.028	85249.2	172885	263000	484876	-180
T24	Silver Ck	2001	6	4.818	104404.5	503021	263000	1151940	-129
T24	Silver Ck	2001	7	0.444	55748.5	24752	263000	106156	-329
T24	Silver Ck	2001	8	0	0	0	263000	0	0
T24	Silver Ck	2001	9	0	0	0	263000	0	0
T24	Silver Ck	2001	10	0	0	0	263000	0	0
Total				7.29		700659		1742973	-149
T25	Slip-Up Ck	2000	7	0.085	43832.87	3726	158000	12209	-228
T25	Slip-Up Ck	2000	8	0.439	294926.8	129473	158000	63056	51
T25	Slip-Up Ck	2000	9	0.117	43832.89	5128	158000	16805	-228
T25	Slip-Up Ck	2000	10	0.125	43832.88	5479	158000	17955	-228
T25	Slip-Up Ck	2001	5	1.2	420359	504431	158000	172364	66
T25	Slip-Up Ck	2001	6	1.111	354345.5	393678	158000	159580	59
T25	Slip-Up Ck	2001	7	0.722	251674	181709	158000	103705	43
T25	Slip-Up Ck	2001	8	0.236	43832.88	10345	158000	33898	-228
T25	Slip-Up Ck	2001	9	0.157	43832.87	6882	158000	22551	-228
T25	Slip-Up Ck	2001	10	0.149	43832.87	6531	158000	21402	-228
Total				4.341		1247381		623525	50

					FLUX Modeled				Reduction Needed
					Loading		Max. Allowed 10%MOS		Monthly
Site	**Stream**	**Year**	**Month**	**Q (hm3)**	**Conc (ppb)**	**Mass (kg)**	**Conc (ppb)**	**Mass (kg)**	**Ave. (%)**
T26	W. Pipeston	2000	7	0.154	102387	15768	158000	22120	-40
T26	W. Pipeston	2000	8	0.008	2175736	17406	158000	1149.091	93
T26	W. Pipeston	2000	9	0.001	17480600	17481	158000	143.6364	99
T26	W. Pipeston	2000	10	0	26153.06	0	158000	0	0
T26	W. Pipeston	2001	3	3.344	53007	177255	158000	480320	-171
T26	W. Pipeston	2001	4	15.303	22281	340966	158000	2198067	-545
T26	W. Pipeston	2001	5	1.164	59405	69147	158000	167192.7	-142
T26	W. Pipeston	2001	6	5.32	32087	170703	158000	764145.5	-348
T26	W. Pipeston	2001	7	1.266	108402	137237	158000	181843.6	-33
T26	W. Pipeston	2001	8	4.433	123268	546447	158000	636740	-17
T26	W. Pipeston	2001	9	0.061	286446	17473	158000	8761.818	50
T26	W. Pipeston	2001	10	0.059	298554	17615	158000	8474.545	52
Total				31.113		1527498		4468958	-193
T27	W. Pipeston	2000	7	0.778	294133.4	228836	158000	111749.1	51
T27	W. Pipeston	2000	8	0.932	323791.8	301774	158000	133869.1	56
T27	W. Pipeston	2000	9	0.721	245200.6	176790	158000	103561.8	41
T27	W. Pipeston	2000	10	2.19	245200.6	536989	158000	314563.6	41
T27	W. Pipeston	2001	3	6.685	462098.4	3089128	158000	960209.1	69
T27	W. Pipeston	2001	4	30.892	457247	14125274	158000	4437215	69
T27	W. Pipeston	2001	5	4.036	358741.2	1447879	158000	579716.4	60
T27	W. Pipeston	2001	6	6.577	422380.8	2777999	158000	944696.4	66
T27	W. Pipeston	2001	7	2.374	356330.1	845928	158000	340992.7	60
T27	W. Pipeston	2001	8	0.637	245200.6	156193	158000	91496.36	41
T27	W. Pipeston	2001	9	0.642	245200.6	157419	158000	92214.55	41
T27	W. Pipeston	2001	10	1.46	245200.6	357993	158000	209709.1	41
Total				57.924		24202201		8319993	66

T28	Pipestone Ck (upper)	2000	7	0.635	107555.1	68297	158000	91209.09091		-34
T28	Pipestone Ck (upper)	2000	8	0.592	132615.1	78508	158000	85032.72727		-8
T28	Pipestone Ck (upper)	2000	9	0.382	198843	75958	158000	54869.09091		28
T28	Pipestone Ck (upper)	2000	10	0.506	155072.1	78466	158000	72680		7
T28	Pipestone Ck (upper)	2001	3	1.987	88678.27	176204	158000	285405.4545		-62
T28	Pipestone Ck (upper)	2001	4	24.144	93767	2263910	158000	3467956.364		-53
T28	Pipestone Ck (upper)	2001	5	10.274	199306.7	2047677	158000	1475720		28
T28	Pipestone Ck (upper)	2001	6	9.49	100227.3	951157	158000	1363109.091		-43
T28	Pipestone Ck (upper)	2001	7	2.43	62311.64	151417	158000	349036.3636		-131
T28	Pipestone Ck (upper)	2001	8	1.063	73807.16	78457	158000	152685.4545		-95
T28	Pipestone Ck (upper)	2001	9	0.839	90444.4	75883	158000	120510.9091		-59
T28	Pipestone Ck (upper)	2001	10	0.909	83555.01	75952	158000	130565.4545		-72
Total						6121887		7648780		-25
T29	Pipestone Ck (lower)	2000	7	2.562	54044.55	138462	158000	367996.3636		-166
T29	Pipestone Ck (lower)	2000	8	2.724	54044.55	147217	158000	391265.4545		-166
T29	Pipestone Ck (lower)	2000	9	2.479	54044.55	133976	158000	356074.5455		-166
T29	Pipestone Ck (lower)	2000	10	2.685	54044.55	145110	158000	385663.6364		-166
T29	Pipestone Ck (lower)	2001	3	3.08	75433.96	232337	158000	442400		-90
T29	Pipestone Ck (lower)	2001	4	49.095	90719.14	4453856	158000	7051827.273		-58
T29	Pipestone Ck (lower)	2001	5	13.35	81230.03	1084421	158000	1917545.455		-77
T29	Pipestone Ck (lower)	2001	6	16.317	82621.58	1348136	158000	2343714.545		-74
T29	Pipestone Ck (lower)	2001	7	4.784	54044.56	258549	158000	687156.3636		-166
T29	Pipestone Ck (lower)	2001	8	3.098	54044.56	167430	158000	444985.4545		-166
T29	Pipestone Ck (lower)	2001	9	2.777	54044.55	150082	158000	398878.1818		-166
T29	Pipestone Ck (lower)	2001	10	2.81	54044.56	151865	158000	403618.1818		-166
Total						8411442		15191125.45		-81
T30	Split Rock Ck (upper)	2000	7	1.268	104497.9	132503	158000	182130.9091		-37
T30	Split Rock Ck (upper)	2000	8	4.319	79271.95	342376	158000	620365.4545		-81
T30	Split Rock Ck (upper)	2000	9	5.883	56313.32	331291	158000	845012.7273		-155
T30	Split Rock Ck (upper)	2000	10	8.008	42751.75	342356	158000	1150240		-236
T30	Split Rock Ck (upper)	2001	3	6.935	387064.6	2684293	158000	996118.1818		63
T30	Split Rock Ck (upper)	2001	4	59.75	155018.9	9262379	158000	8582272.727		7
T30	Split Rock Ck (upper)	2001	5	16.844	373815.3	6296545	158000	2419410.909		62
T30	Split Rock Ck (upper)	2001	6	9.532	302449	2882944	158000	1369141.818		53
T30	Split Rock Ck (upper)	2001	7	3.185	107482.9	342333	158000	457481.8182		-34
T30	Split Rock Ck (upper)	2001	8	1.137	301144.1	342401	158000	163314.5455		52
T30	Split Rock Ck (upper)	2001	9	1.067	310488.2	331291	158000	153260		54
T30	Split Rock Ck (upper)	2001	10	1.057	313476.3	331344	158000	151823.6364		54
Total						23622056		17090572.73		28
T31	Split Rock Ck (lower)	2000	7	1.036	87470.9	90620	158000	148807.2727		-64
T31	Split Rock Ck (lower)	2000	8	3.359	87470.91	293815	158000	482474.5455		-64
T31	Split Rock Ck (lower)	2000	9	1.632	87470.91	142753	158000	234414.5455		-64
T31	Split Rock Ck (lower)	2000	10	1.842	87470.91	161121	158000	264578.1818		-64
T31	Split Rock Ck (lower)	2001	3	11.233	233968.4	2628167	158000	1613467.273		39
T31	Split Rock Ck (lower)	2001	4	57.202	401876.3	22988128	158000	8216287.273		64
T31	Split Rock Ck (lower)	2001	5	57.055	410954.7	23447020	158000	8195172.727		65
T31	Split Rock Ck (lower)	2001	6	50.305	410954.8	20673081	158000	7225627.273		65
T31	Split Rock Ck (lower)	2001	7	46.632	404175	18847489	158000	6698050.909		64
T31	Split Rock Ck (lower)	2001	8	41.794	396581.3	16574719	158000	6003138.182		64
T31	Split Rock Ck (lower)	2001	9	21.035	214861.1	4519603	158000	3021390.909		33
T31	Split Rock Ck (lower)	2001	10	42.122	385722.8	16247416	158000	6050250.909		63
Total						126613932		48153660		62

T32	Beaver Ck (u	2000	7	0.709	169232.5	119986	263000	169515.45	-41
T32	Beaver Ck (u	2000	8	0.194	169232.5	32831	263000	46383.636	-41
T32	Beaver Ck (u	2000	9	1.047	169232.5	177186	263000	250328.18	-41
T32	Beaver Ck (u	2000	10	1.282	169232.5	216956	263000	306514.55	-41
T32	Beaver Ck (u	2001	3	3.116	758658.8	2363981	263000	745007.27	68
T32	Beaver Ck (u	2001	4	11.497	758658.8	8722300	263000	2748828.2	68
T32	Beaver Ck (u	2001	5	6.249	707695.3	4422388	263000	1494079.1	66
T32	Beaver Ck (u	2001	6	6.907	638196	4408020	263000	1651400.9	63
T32	Beaver Ck (u	2001	7	5.196	513897.3	2670210	263000	1242316.4	53
T32	Beaver Ck (u	2001	8	2.848	200562.3	571201	263000	680930.91	-19
T32	Beaver Ck (u	2001	9	2.005	169232.5	339311	263000	479377.27	-41
T32	Beaver Ck (u	2001	10	1.901	169232.5	321711	263000	454511.82	-41
Total				42.951		24366082		10269194	58

T33	Beaver Ck (l	2000	7	0.349	181426	63318	263000	83442.727	-32
T33	Beaver Ck (l	2000	8	0.073	181426	13244	263000	17453.636	-32
T33	Beaver Ck (l	2000	9	0.237	181426	42998	263000	56664.545	-32
T33	Beaver Ck (l	2000	10	0.38	181426	68942	263000	90854.545	-32
T33	Beaver Ck (l	2001	3	8.289	325139	2695079	263000	1981824.5	26
T33	Beaver Ck (l	2001	4	45.302	321425	14561209	263000	10831296	26
T33	Beaver Ck (l	2001	5	13.334	285199	3802837	263000	3188038.2	16
T33	Beaver Ck (l	2001	6	20.146	300744	6058781	263000	4816725.5	21
T33	Beaver Ck (l	2001	7	10.311	265704	2739673	263000	2465266.4	10
T33	Beaver Ck (l	2001	8	2.549	181426	462454	263000	609442.73	-32
T33	Beaver Ck (l	2001	9	1.168	181426	211905	263000	279258.18	-32
T33	Beaver Ck (l	2001	10	1.019	181426	184873	263000	243633.64	-32
Total				103.157		30905312		24663901	20

Appendix NN.
SDM Landuse Breakout by Site

Site	Water	% Water	Trees	% Trees	Artifical	% Artificial	Barren	% Barren	Grass	% Grass	LEP Cropland	% LEP Cropland	MEP Cropland	% MEP Cropland	HEP Cropland	% HEP Cropland	Total Acres
R01	847.31	1.68	1588.98	3.15	468.58	0.93	10.45	0.02	21731.28	43.05	24367.94	48.27	520.84	1.03	949.16	1.88	50484.53
R02	5.78	0.14	219.94	5.22	70.50	1.67	0.00	0.00	3071.43	72.94	800.38	19.01	0.00	0.00	43.14	1.02	4211.18
R03	2964.90	3.47	2462.52	2.88	1575.86	1.84	16.23	0.02	34016.33	39.78	42211.62	49.37	979.18	1.15	1276.74	1.49	85503.40
R04	6.23	0.25	136.77	5.46	40.47	1.62	0.00	0.00	901.12	36.00	1394.83	55.72	20.46	0.82	3.34	0.13	2503.22
R05	72.28	0.14	1462.56	2.87	689.26	1.35	58.04	0.11	16729.78	32.87	31050.51	61.01	643.15	1.26	191.92	0.38	50897.51
R06	177.91	0.64	930.70	3.34	576.66	2.07	40.92	0.15	10558.41	37.88	14594.12	52.36	650.71	2.33	341.81	1.23	27871.25
R07	96.29	0.46	545.08	2.59	271.54	1.29	21.35	0.10	7956.89	37.74	11427.51	54.20	586.22	2.78	178.36	0.85	21083.24
R08	108.97	0.20	593.34	1.08	908.91	1.65	216.83	0.39	15008.88	27.32	33417.21	60.83	2151.62	3.92	2529.02	4.60	54934.78
R09	77.17	0.35	594.45	2.66	246.41	1.10	1.11	0.00	7551.92	33.80	12310.84	55.09	259.53	1.16	1304.54	5.84	22345.97
R10	2.00	0.04	46.03	0.96	198.82	4.14	0.00	0.00	1430.63	29.82	3117.46	64.99	0.67	0.01	1.33	0.03	4796.95
R11	86.73	0.30	687.63	2.37	4744.69	16.35	0.00	0.00	11216.91	38.66	9966.41	34.35	952.27	3.28	1360.80	4.69	29015.45
R12	54.04	0.28	514.39	2.68	1164.66	6.06	0.00	0.00	7386.46	38.43	6086.81	31.67	2127.61	11.07	1886.09	9.81	19220.06
R13	69.16	0.29	529.51	2.23	452.79	1.91	8.23	0.03	9321.25	39.33	9649.95	40.72	1058.80	4.47	2607.75	11.00	23697.43
T01	14.01	0.04	373.17	1.19	211.05	0.68	12.90	0.04	11011.20	35.24	18826.87	60.25	642.26	2.06	157.90	0.51	31249.35
T02	10.23	0.02	525.51	0.96	393.19	0.72	0.00	0.00	18747.03	34.13	34371.26	62.57	628.03	1.14	253.97	0.46	54929.22
T03	3.11	0.02	274.43	1.51	91.85	0.50	1.11	0.01	6905.88	37.91	10181.46	55.90	633.59	3.48	122.98	0.68	18214.41
T04	5.34	0.03	168.57	0.96	175.69	1.00	0.00	0.00	6683.04	38.19	9967.74	56.95	363.39	2.08	137.88	0.79	17501.65
T05	7.78	0.11	115.42	1.67	801.94	11.59	2.00	0.03	2951.34	42.64	3018.28	43.61	22.24	0.32	1.78	0.03	6920.78
T06	47.59	0.13	242.18	0.67	379.84	1.05	9.12	0.03	21407.48	59.18	11397.71	31.51	1762.00	4.87	930.48	2.57	36176.40
T07	0.00	0.00	6.89	0.46	13.12	0.87	0.00	0.00	783.26	51.80	681.40	45.07	8.45	0.56	18.90	1.25	1512.03
T08	6.00	0.02	293.78	1.15	390.74	1.53	25.57	0.10	8635.63	33.81	15392.50	60.27	646.71	2.53	149.22	0.58	25540.16
T09	2.45	0.01	453.23	1.14	347.60	0.88	8.67	0.02	11794.90	29.74	26463.97	66.73	497.26	1.25	92.29	0.23	39660.37
T10	34.03	0.25	326.91	2.38	2458.74	17.87	0.00	0.00	5141.88	37.36	4481.60	32.57	344.04	2.50	974.51	7.08	13761.72
T11	9.12	0.03	219.72	0.71	372.95	1.21	6.67	0.02	10426.31	33.89	19191.81	62.39	346.71	1.13	188.14	0.61	30761.43
T12	3.34	0.14	34.69	1.41	21.57	0.88	0.00	0.00	1112.84	45.35	1000.98	40.79	231.95	9.45	48.48	1.98	2453.85
T13	323.36	0.90	479.70	1.34	418.54	1.17	21.57	0.06	10490.36	29.22	23830.42	66.37	276.43	0.77	66.05	0.18	35906.42
T14	2345.77	3.25	1482.45	2.05	733.66	1.02	33.36	0.05	19482.48	26.96	46209.97	63.95	1653.02	2.29	314.24	0.43	72254.96
T15	1590.76	3.19	895.34	1.79	216.16	0.43	29.80	0.06	13683.43	27.42	28865.78	57.84	3614.50	7.24	1009.65	2.02	49905.43
T16	449.23	7.63	154.78	2.63	35.14	0.60	8.45	0.14	1552.28	26.37	3015.61	51.23	267.76	4.55	403.42	6.85	5886.66
T17	1321.89	14.67	237.73	2.64	95.18	1.06	0.00	0.00	2490.32	27.64	3659.87	40.62	930.26	10.32	274.65	3.05	9009.91
T18	392.74	2.23	578.66	3.29	181.25	1.03	7.12	0.04	6863.18	39.05	7977.80	45.39	800.38	4.55	775.25	4.41	17576.37
T19	997.64	2.46	516.83	1.27	162.34	0.40	50.26	0.12	7919.75	19.53	21677.91	53.46	5366.27	13.23	3857.35	9.51	40548.37
T20	1256.06	2.95	1235.15	2.90	88.96	0.21	14.90	0.03	11623.21	27.26	21208.22	49.74	4993.99	11.71	2220.12	5.21	42640.61

T21	998.09	1.46	1358.36	1.99	409.86	0.60	85.40	0.13	20022.66	29.33	38301.34	56.11	4366.41	6.40	2718.27	3.98	68260.39
T22	9.12	0.03	62.27	0.20	390.29	1.27	115.87	0.38	10009.55	32.63	7099.13	23.14	4295.46	14.00	8695.67	28.35	30677.37
T23	661.17	2.09	691.63	2.19	453.01	1.43	0.00	0.00	9469.81	29.94	16781.10	53.06	2645.77	8.37	922.03	2.92	31624.53
T24	30.91	0.17	348.26	1.93	162.34	0.90	69.39	0.38	5582.21	30.96	8329.62	46.19	1589.87	8.82	1919.00	10.64	18031.60
T25	1.78	0.01	93.85	0.64	69.16	0.47	28.02	0.19	3860.91	26.41	5843.07	39.97	3043.63	20.82	1679.04	11.48	14619.47
T26	0.00	0.00	104.75	0.32	179.91	0.54	26.91	0.08	5670.72	17.18	26264.70	79.56	695.41	2.11	69.39	0.21	33011.79
T27	21.79	0.10	116.98	0.55	63.16	0.29	12.45	0.06	5247.51	24.49	5508.60	25.71	5188.14	24.22	5266.20	24.58	21424.83
T28	0.00	0.00	10.45	0.29	11.12	0.31	0.00	0.00	985.85	27.61	2562.60	71.78	0.00	0.00	0.00	0.00	3570.03
T29	22.91	0.06	98.96	0.26	207.27	0.55	30.69	0.08	5900.67	15.74	30741.19	81.98	425.21	1.13	71.39	0.19	37498.29
T30	1.78	0.17	38.92	3.65	8.67	0.81	0.00	0.00	227.95	21.39	547.97	51.42	90.29	8.47	150.11	14.09	1065.69
T31	82.28	0.31	368.28	1.37	153.67	0.57	29.80	0.11	7158.96	26.62	7737.62	28.77	4633.50	17.23	6728.41	25.02	26892.51
T32																	
T33	28.02	0.10	174.13	0.65	188.14	0.70	26.02	0.10	7572.60	28.12	10686.73	39.68	4561.66	16.94	3695.68	13.72	26932.99

Appendix OO.
AgNPS Feedlot Ratings

AGNPS Feedlot Ratings

	Rating					
Site	**0-14**	**15-36**	**37-49**	**50-71**	**72-102**	**Total Feedlots**
T01	0	2	4	8	0	14
T02	2	6	8	12	1	29
T03	0	1	3	4	2	10
T04	5	3	0	8	0	16
T05	0	0	0	0	0	0
T06	10	3	1	3	0	17
T07	2	0	1	1	0	4
T08	8	4	8	9	0	29
T09	5	3	10	6	2	26
T10	NA	NA	NA	NA	NA	0
T11	11	2	7	6	2	28
T12	0	0	0	0	0	0
T13	6	6	8	10	1	31
T14	NA	NA	NA	NA	NA	0
T15	4	6	4	4	2	20
T16	2	0	1	0	1	4
T17	NA	NA	NA	NA	NA	0
T18	4	1	2	0	0	7
T19	3	5	5	7	1	21
T20	13	5	6	12	4	40
T21	24	18	13	17	8	80
T22	2	9	6	5	3	25
T23	7	3	2	3	1	16
T24	3	2	5	2	0	12
T25	3	1	2	5	1	12
T26	8	6	5	8	1	28
T27	8	5	5	2	1	21
T28	0	1	1	2	0	4
T29	5	9	5	6	1	26
T30	0	1	0	1	0	2
T31	9	2	1	6	1	19
T32	NA	NA	NA	NA	NA	0
T33	9	6	4	5	0	24
R01	NA	NA	NA	NA	NA	0
R02	8	1	2	2	0	13
R03	11	10	11	15	1	48
R04	2	1	0	2	2	7
R05	17	5	14	11	4	51
R06	19	8	6	4	0	37
R07	4	4	2	1	0	11
R08	18	10	17	18	3	66
R09	6	4	2	0	2	14
R10	0	0	0	0	0	0
R11	1	0	0	0	0	1
R12	2	1	1	0	0	4
R13	1	2	3	3	1	10
Total	**242**	**156**	**175**	**208**	**46**	**827**

NA = outsitde the project study area even though the site was monitored for WQ

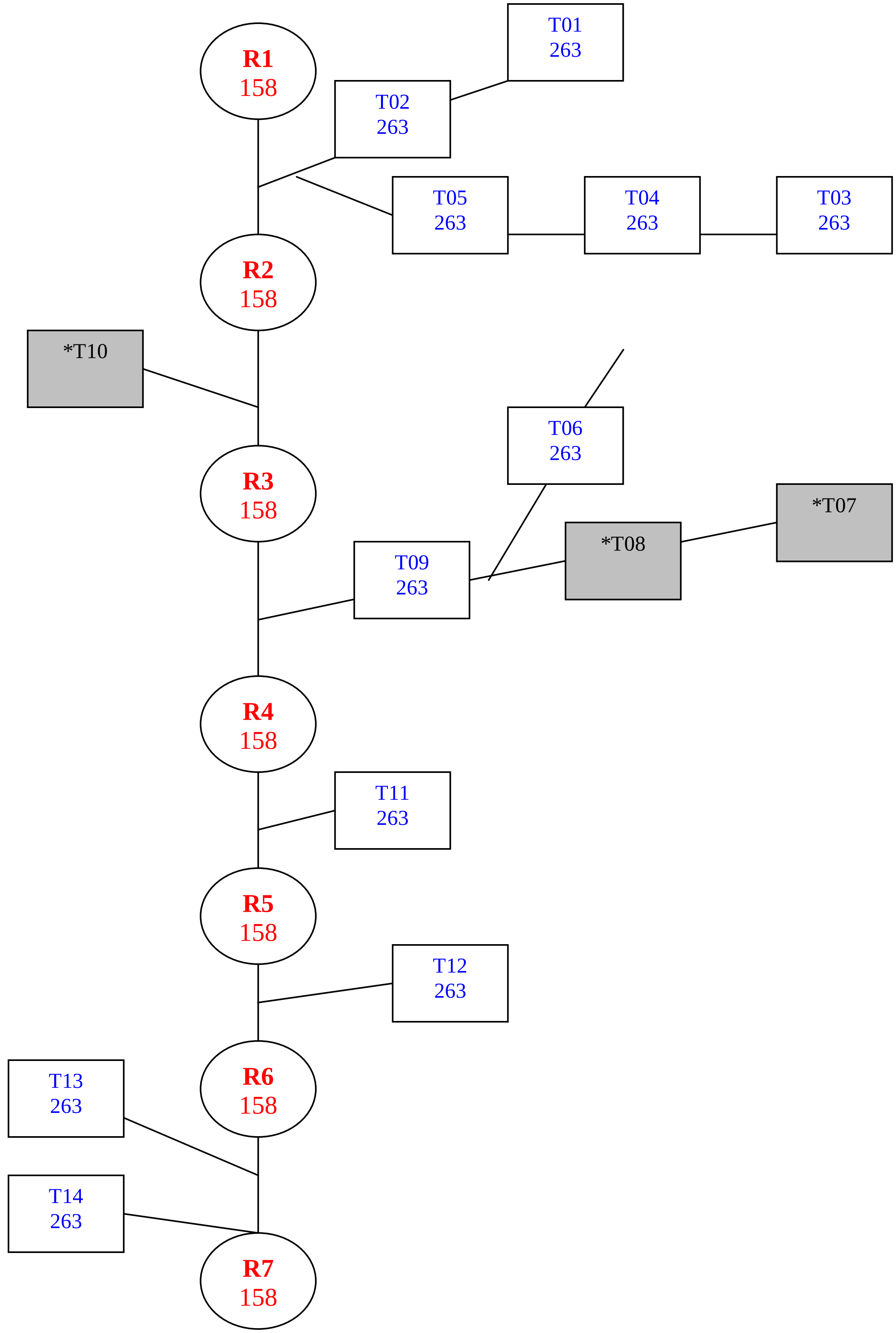
Appendix PP.
AgNPS Model Outputs for Feedlots in the CBSRW Study Area

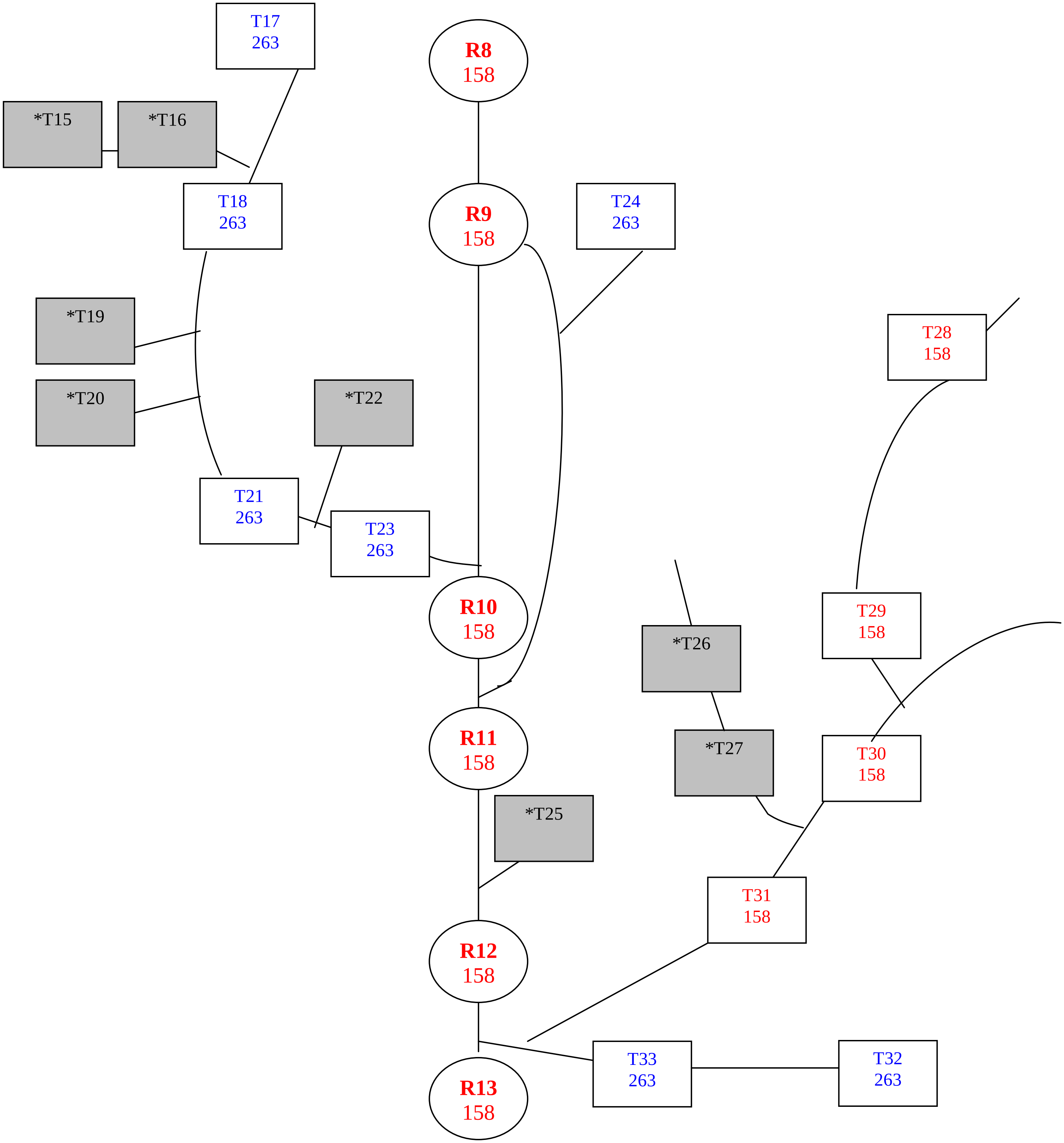
AgNPS Model Outputs for Feedlots in the CBSRW Study Area

Site	Density	Mean PO4 (ppm)	Mean COD (ppm)	Mean PO4 (lbs)	Mean COD (lbs)	Sum Phos (ppm)	Sum COD (ppm)	Sum Phos (lbs)	Sum COD (lbs)
R02	13	9	760	26	1816	112	9880	332	23606
R03	48	22	1255	73	4209	1038	60223	3508	202009
R04	7	33	1745	221	11697	230	12217	1546	81882
R05	51	22	1188	86	4437	1127	60564	4411	226312
R06	37	15	768	33	1605	557	28423	1205	59382
R07	11	11	546	30	1690	116	6009	330	18592
R08	66	26	1351	86	4382	1705	89173	5670	289232
R09	14	21	1041	106	4942	300	14570	1485	69187
R11	1	0	0	0	0	0	0	0	0
R12	4	9	438	25	1144	38	1752	99	4575
R13	10	30	1533	119	6072	297	15326	1191	60717
T01	14	37	1953	105	5890	519	27339	1464	82461
T02	29	25	1419	118	6485	724	41139	3412	188058
T03	10	28	1620	183	9131	280	16204	1827	91310
T04	16	24	1220	82	4209	382	19516	1314	67351
T06	17	17	801	35	1627	295	13619	589	27654
T07	4	12	581	56	2804	48	2323	223	11215
T08	29	36	1797	69	3385	1043	52126	1997	98175
T09	26	28	1520	95	4798	741	39518	2472	124737
T11	28	22	1135	106	5119	627	31792	2968	143330
T13	31	30	1674	83	4608	919	51889	2584	142840
T15	20	21	1054	76	3754	423	21084	1524	75087
T16	4	17	919	118	6228	69	3676	471	24914
T18	7	8	589	16	1108	58	4122	111	7755
T19	21	29	1443	121	5700	607	30310	2538	119693
T20	40	23	1282	121	7705	923	51295	4858	308192
T21	80	22	1146	115	5909	1723	91691	9169	472742
T22	25	24	1223	130	6718	600	30568	3256	167962
T23	16	20	1010	66	3352	325	16165	1064	53627
T24	12	24	1208	55	3062	292	14491	663	36742
T25	12	27	1346	193	8075	322	16153	2314	96897
T26	28	27	1404	94	4930	753	39316	2625	138039
T27	21	14	789	62	4107	299	16578	1305	86254
T28	4	20	982	74	3624	80	3930	296	14494
T29	26	28	1400	75	3670	733	36398	1948	95414
T30	2	37	1914	58	3013	74	3829	116	6027
T31	19	27	1541	111	6255	521	29286	2110	118840
T33	24	21	1027	42	2227	499	24637	1001	53456

Appendix QQ.
Flow Chart of the TSS Standards Assigned to Each Monitoring Location

Total Suspended Solids Flow Chart



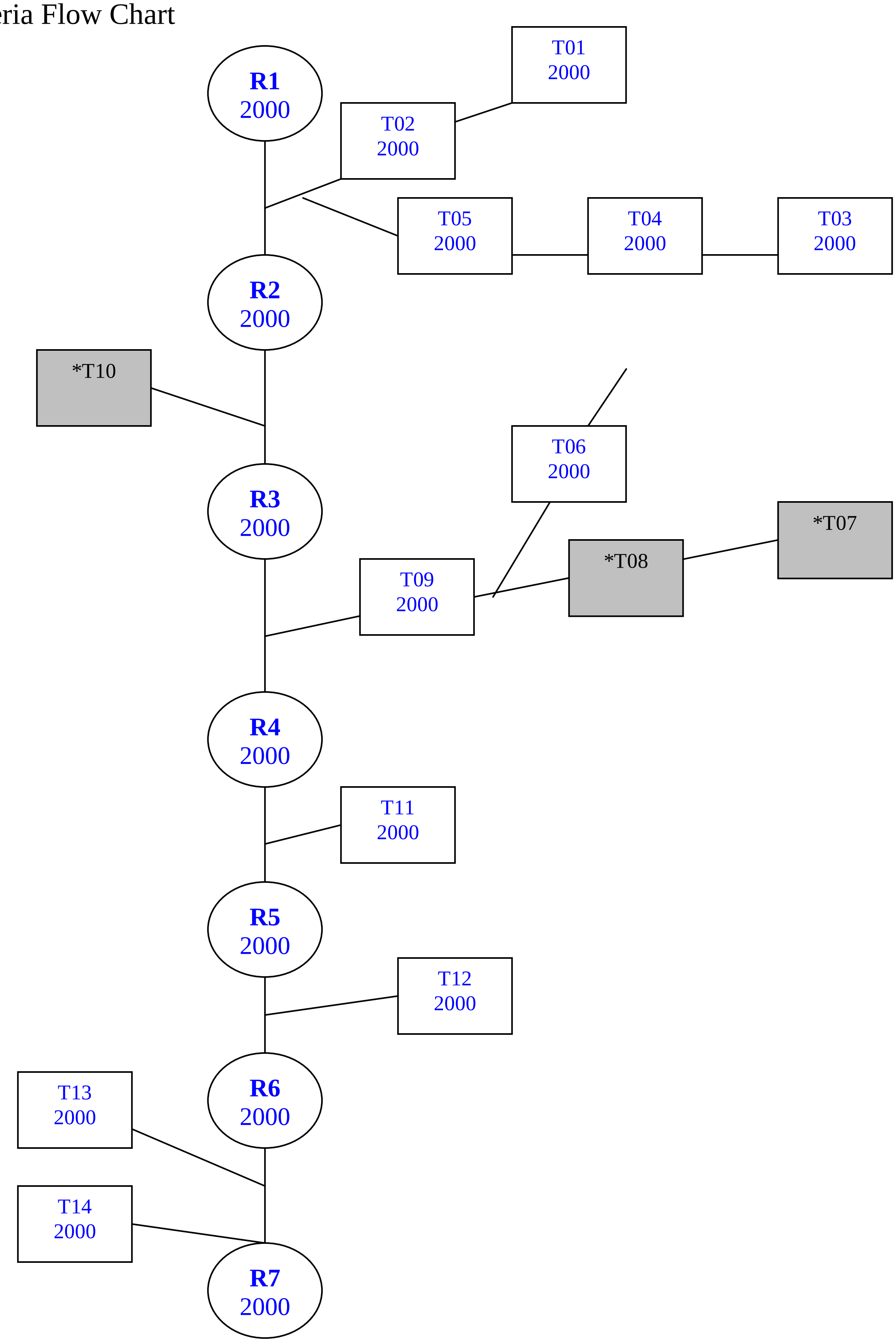


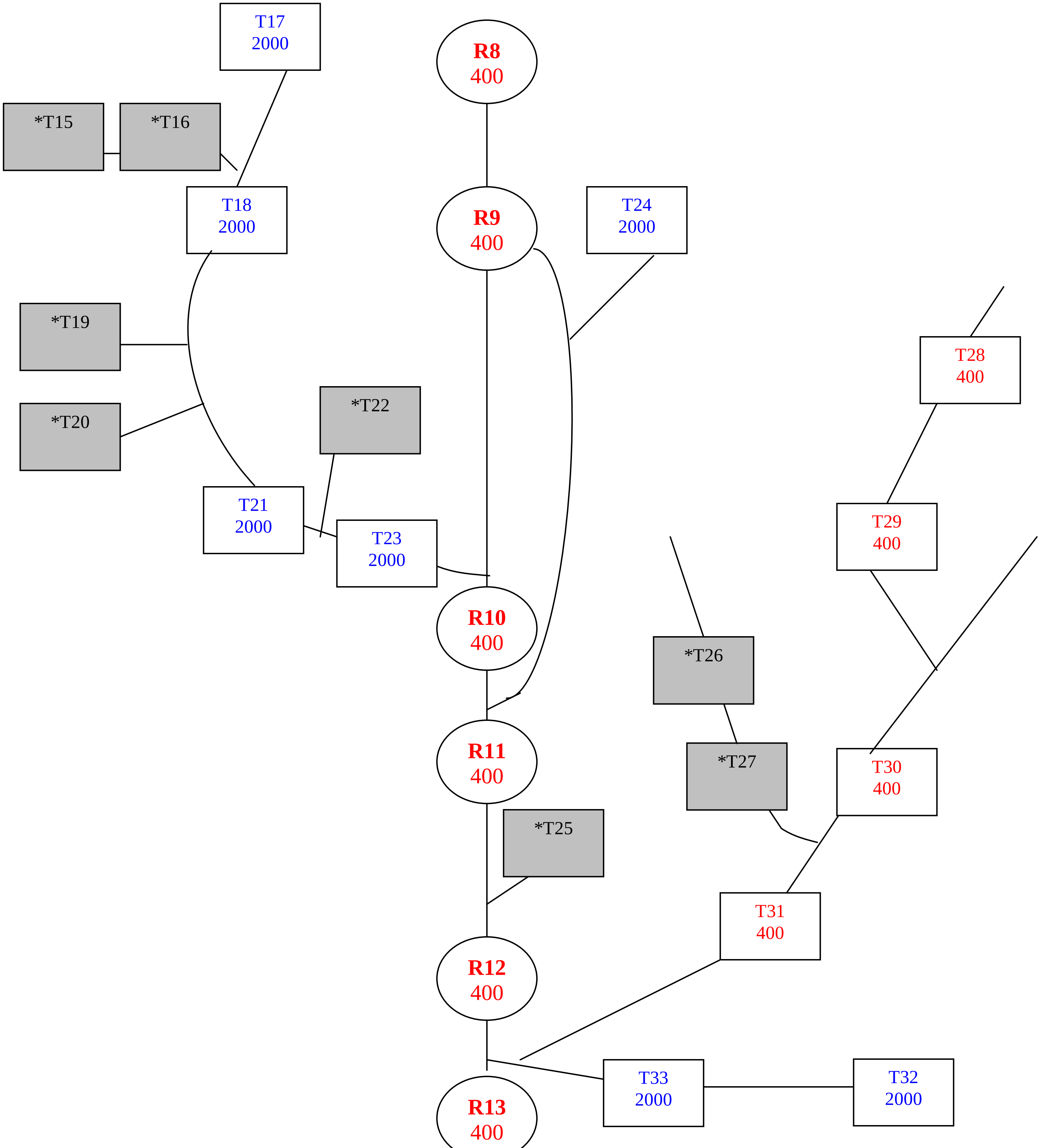
* denotes no water quality standard for the designated site

Appendix QQ

Appendix RR.
Flow Chart of the Fecal Coliform Bacteria Standards Assigned to Each Monitoring Location

Fecal Coliform Bacteria Flow Chart



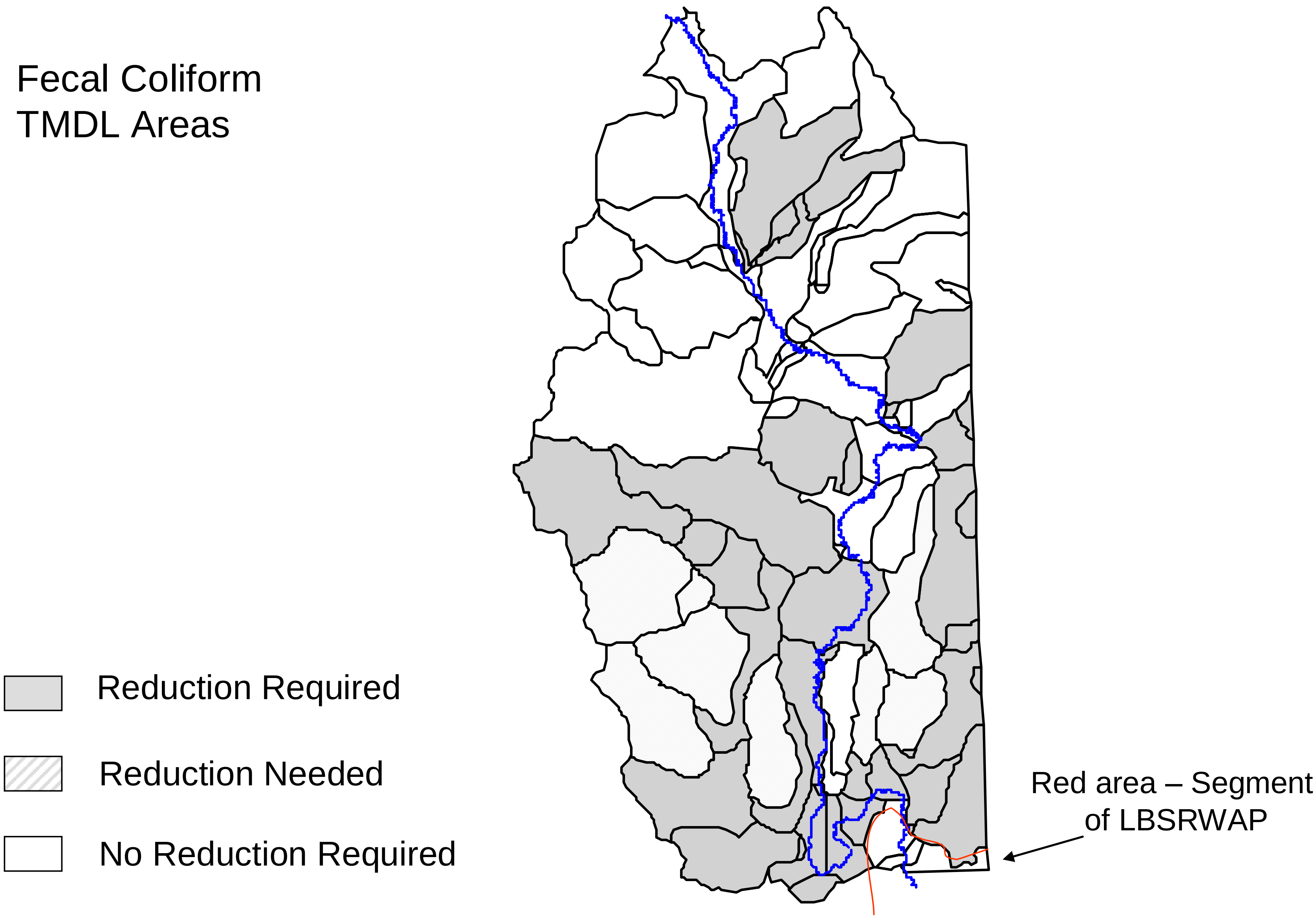


* denotes no water quality standard for the designated site

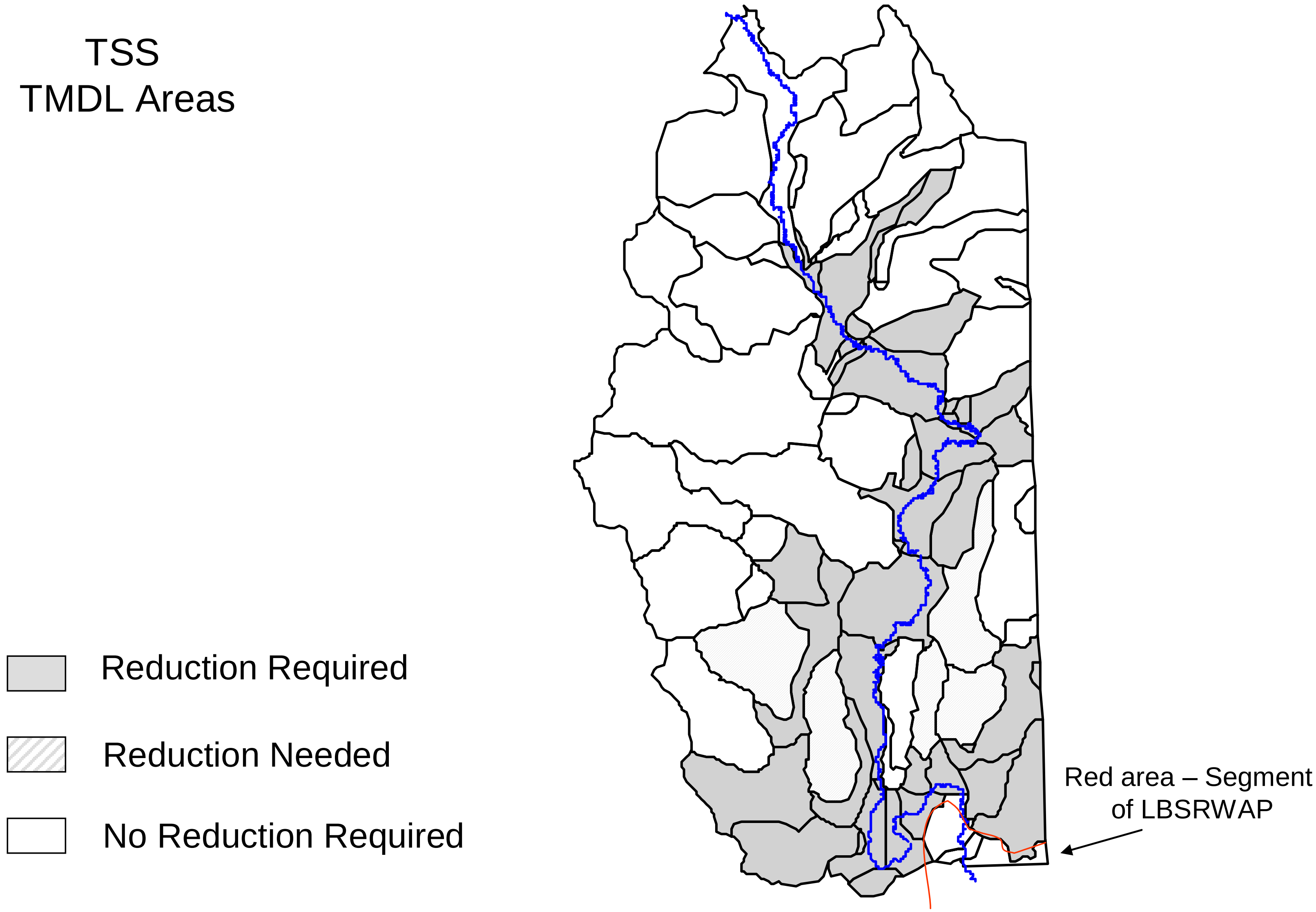
Appendix RR

Appendix RR1.
Refined Reduction Maps Based on TMDL Results

Fecal Coliform TMDL Areas



TSS
TMDL Areas



Appendix SS.
TMDL – Brookings to I-29 (TSS)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Total Suspended Solids)

for the

Big Sioux River
(Brookings to I-29)

(HUC 10170202)

Brookings and Moody Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Brookings to I-29 Total Maximum Daily Load

Waterbody Type:	River Segment
Assessment Unit ID:	SD-BS-R-Big_Sioux_06
303(d) Listing Parameter:	Suspended Solids
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Domestic Water Supply Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Segment:	15.2 miles
Size of Watershed:	586,150 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models including Flow Duration Interval Zones and Sediment Delivery Model (SDM)
Location:	HUC Code: 10170202
Goal:	Reduce the pounds of total suspended solids per day by 19 percent during moist conditions
Target:	≤ 158 mg/L of total suspended solids (any one sample)

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The section of the Big Sioux River from Brookings to I-29 is a 15.2 mile segment with a watershed of approximately 586,150 acres, which includes LMUs R1, R2, R3, R4, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, B, C, D, F, I, J, K, L, N, O, and MM. The segment is located within the Big Sioux River Basin (HUC 10170202) in south central Brookings County, and in the northwest area of Moody County, South Dakota. The watershed of this segment lies within Brookings, Moody, and Lake Counties as shown by the shaded region in Figure 1. This segment is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

This segment is influenced by the major tributaries of North Deer Creek, Six Mile Creek, Deer Creek, Medary Creek, the Lake Campbell Outlet, and also anything occurring within the Big Sioux River above Brookings. Initially, the 1998 South Dakota 303(d) Waterbody List identified the segment from Brookings to I-29 for TMDL development due to not meeting the water quality criteria for suspended solids. Information supporting this listing was derived from statewide ambient monitoring data and the 1996 305(b) report. This segment was also identified in the 2004 South Dakota 303(d) Waterbody List as not supporting for its beneficial use warmwater semi-permanent fish life propagation, due to excessive suspended solids. However, this segment was in full support of all its beneficial uses for the 2006 303(d) Waterbody list. The

Central Big Sioux River Watershed Assessment Project found this segment is not meeting the water quality criteria for total suspended solids. Appendix B of the Assessment Report summarizes the data collected during the period of July 1999 to October 2000.

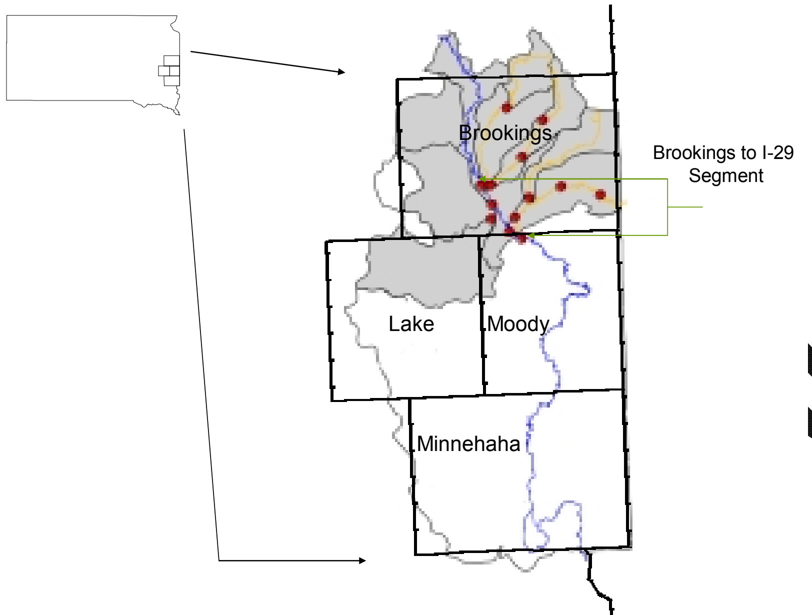


Figure 1. Location of the Brookings to I-29 Segment and its Watershed in South Dakota

Problem Identification

The Brookings to I-29 Segment is a small portion of the Big Sioux River, starting at monitoring site R01 and ending at monitoring site R04. The watershed area shown in Figure 2 drains approximately 96 percent grass/grazing land and cropland acres. This includes the receiving waters of North Deer Creek (T01-T02), Six Mile Creek (T03-T05), Deer Creek (T06), Medary Creek (T07-T09) and the Lake Campbell Outlet (T10). The municipalities of White, Brookings, and Aurora are located in this area.

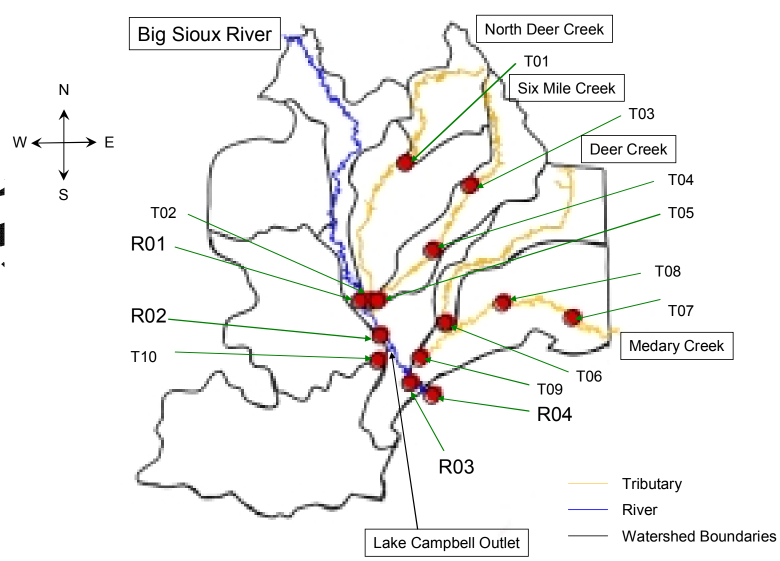


Figure 2. Big Sioux River Segment (Brookings to I-29) Watershed

The river segment between Brookings and I-29 (R01 to R04) was found to carry excessive sediment which degrades water quality. This segment of the Big Sioux River is considered impaired because more than 10 percent of the values (of more than 20 samples) exceeded the numeric criteria of ≤ 158 mg/L of total suspended solids per grab sample.

Four project monitoring locations (R01-R04) were set up on this segment of the Big Sioux River, and two DENR ambient water quality monitoring sites (WQM 62 and WQM 2) coincided with two of the project sites. A total of 126 water quality samples were taken from the four monitoring locations on the Big Sioux River. Of these 126 samples, 21 percent were violating the water quality standards (Table 1). This 21 percent indicates that this segment is not meeting the water quality criteria for beneficial use (5) Warmwater Semi-permanent Fish Life Propagation. The excess sediment is believed to be coming from cropland runoff and bed/bank erosion.

Table 1. Summary of Total Suspended Solids Data for the Brookings to I-29 Segment

Parameter Causing Impairment	Number of Samples	Percent of Samples >158 mg/L	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
TSS	126	20.6	4	326

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

The Big Sioux River segment from Brookings to I-29 has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Domestic water supply
- Warmwater semi-permanent fish propagation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

The tributaries flowing into this segment of the Big Sioux River have been assigned a range of beneficial uses as shown by the shaded areas in Table 2.

Table 2. Tributary Sites and Their Beneficial Use Classification

	Tributaries									
Creek Name	North Deer		Six Mile			Deer	Medary			Campbell
Beneficial Uses	T01	T02	T03	T04	T05	T06	T07	T08	T09	T10
Warmwater Semi-permanent Fish Life Propagation										
Warmwater Marginal Fish Life Propagation										
Immersion Recreation										
Limited Contact Recreation										
Fish & Wildlife Propagation, Recreation & Stock Watering										
Irrigation										

Individual parameters determine the support of beneficial uses. This segment experiences in-stream total suspended solid loading from bed and bank erosion and also external total suspended solid loading from its watershed. This segment is identified in both the 1998 and 2004 South Dakota Waterbody List as not supporting its warmwater semi-permanent fish life

propagation beneficial use. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state.
To assess the status of the beneficial uses for this river segment, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Water samples from both the East Dakota Water Development District and the SD DENR ambient water quality monitoring program were utilized.

The Brookings to I-29 Big Sioux River Segment currently has a numeric standard of ≤ 158 mg/L for TSS. Assessment monitoring indicates that there is a 19 percent exceedence in TSS during moist conditions. Soils of this area are low in erosion potential. Therefore, this sediment problem is likely due to bed and bank erosion of the Big Sioux River itself, and also poor riparian areas. Excessive TSS can decrease water clarity and increase water temperature. Due to its adsorbing quality, sediment can also carry nutrients, such as phosphorus. This excess in sediment can have adverse affects on fish and other aquatic life. Theoretically, sediment accumulates as it moves downstream. Therefore, the loading at the most downstream monitoring site (R04) determined the reductions required for this segment of the Big Sioux River.

A flow duration interval with hydrologic zones approach was used to assess this river segment. This methodology, developed by Dr. Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

The most downstream monitoring location (R04) was used to assess this stream using the flow duration interval method. Of the 15 water samples collected at this location, five (or 33 percent) violated the water quality standards for total suspended solids. Based on the water quality violations, the Brookings to I-29 segment of the Big Sioux River does not currently support its assigned beneficial use of Warmwater Semi-permanent Fish Life Propagation. This segment requires reducing the pounds of total suspended solids per day, during moist conditions, by 19 percent (Table 3).

Table 3. Brookings to I-29 Total Suspended Solids Reductions

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	-----	9.62E+02	5.92E+02	2.13E+02	-----
X	Flow Median (cfs)	2020.00	526.50	170.00	50.00	7.50
=	Existing	-----	5.07E+05	1.01E+05	1.07E+04	-----
	Target Load (at 158 mg/L)	1.72E+06	4.49E+05	1.45E+05	4.26E+04	6.39E+03
	% Reduction w/MOS	-----	19	0	0	-----

Note: units are pounds/day

Each of the tributaries entering this segment was assessed for their level of sediment contribution. All five tributaries are currently supporting their beneficial uses at the current numeric standard of ≤ 263 mg/L of total suspended solids and require zero reduction in sediment loading (See Analysis and Summary Section of Assessment Report). When a more stringent standard of ≤ 158 mg/L is applied to each of these tributaries, they are fully supporting of beneficial use warmwater semi-permanent fish propagation and do not require reductions in sediment. Therefore, improvement to water quality in the fore mentioned tributaries is unnecessary. Focus should be on the immediate area of the Big Sioux River.

A target reduction of 19 percent during moist conditions will improve sediment levels of the Brookings to I-29 segment of the Big Sioux River to an acceptable daily load, with fewer violations of water quality and full support of its beneficial uses.

Pollutant Assessment

Point Sources

There are five NPDES facilities located within this watershed (Table 4). Total contribution from these facilities during the study period is insignificant, at 0.093 percent. Calculations used total kg for all facilities divided by the total kg from Site R04. The potential load from the facilities is shown in Table 3.

Table 4. NPDES Facilities.

Facility Name	Permit Number	TSS lbs/day
Aurora, City of	SD0021661	183.5
Brookings, City of	SD0023388	2,253.3
South Dakota State University	SD0026832	0.0
VeraSun Energy Corporation	SD0027898	1,799.8
White, City of	SD0021636	105.8

The City of Brookings is also covered for discharges associated with medium municipal separate storm sewer systems (Phase II - MS4) (NPDES Permit #: SDR41A003). The General Surface Water Discharge Permit for Small Municipal Separate Storm Sewer Systems in South Dakota contains requirements that are based on technology considerations, Best Management Practices (BMPs), and other conditions applicable to the types of storm water generated within and discharged from municipal systems.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of total suspended solids include loadings from surface runoff, bed and bank erosion, cropland erosion, construction erosion, and cropland erosion. Figure 3 depicts the flow of water in the watershed and shows the estimated reductions needed at each monitoring site.

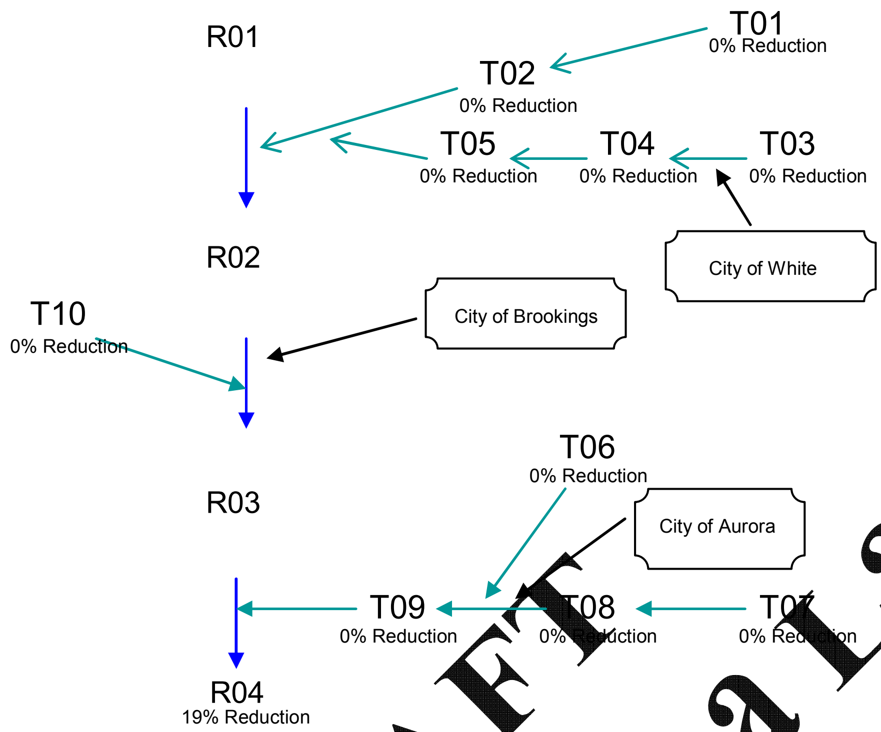


Figure 3. Water Flow and Estimated Reductions in the Watershed

Upland runoff is probably only occurring from the east, as the area to the west is game production land and is mostly in grasses. Analysis of the sediment loadings along each monitoring station of this segment indicates probable occurrences of deposition between Sites R01 and R02, and also between Sites R03 and R04. Increases in sediment loads near Site R03 may indicate urban runoff, upland runoff, and/or bed and bank erosion.

Linkage Analysis

Water quality data was collected at four Big Sioux River sites, nine tributary sites, and one lake outlet. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10 percent of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Sediment Delivery Model (SDM) was used to define critical non-point source (NPS) pollution cells within the watershed (those with high sediment) and estimate the effective percent reduction needed in the watershed by adding various Best Management Practices (BMPs). See the Modeling and Results section of the final report for a complete summary of the results. The SDM was used to predict sediment loadings during 2, 5, 10, and 20 year (24 hour) rainfall events (Appendix Y, Assessment Report). Then best management practices, such as stream buffers and tillage practices, were applied to find the achievable percent reductions (Appendix Z, Assessment Report).

The Flow Duration Interval Zone method calculates total suspended solids loading, (concentration) × (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of sediment for the Brookings to I-29 segment of the Big Sioux River, the range of flows from the monitoring location were divided into “flow zones”. The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-range (40-60), Dry (60-90), and Low (90-100). Excessive sediment loadings are occurring during moist conditions. Flow duration intervals were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 4, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Attachment 1 contains detailed exceedence information). Table 5 depicts the allowable sediment load during the study for peak flow, low flow, and 5th percentile increments in flow.

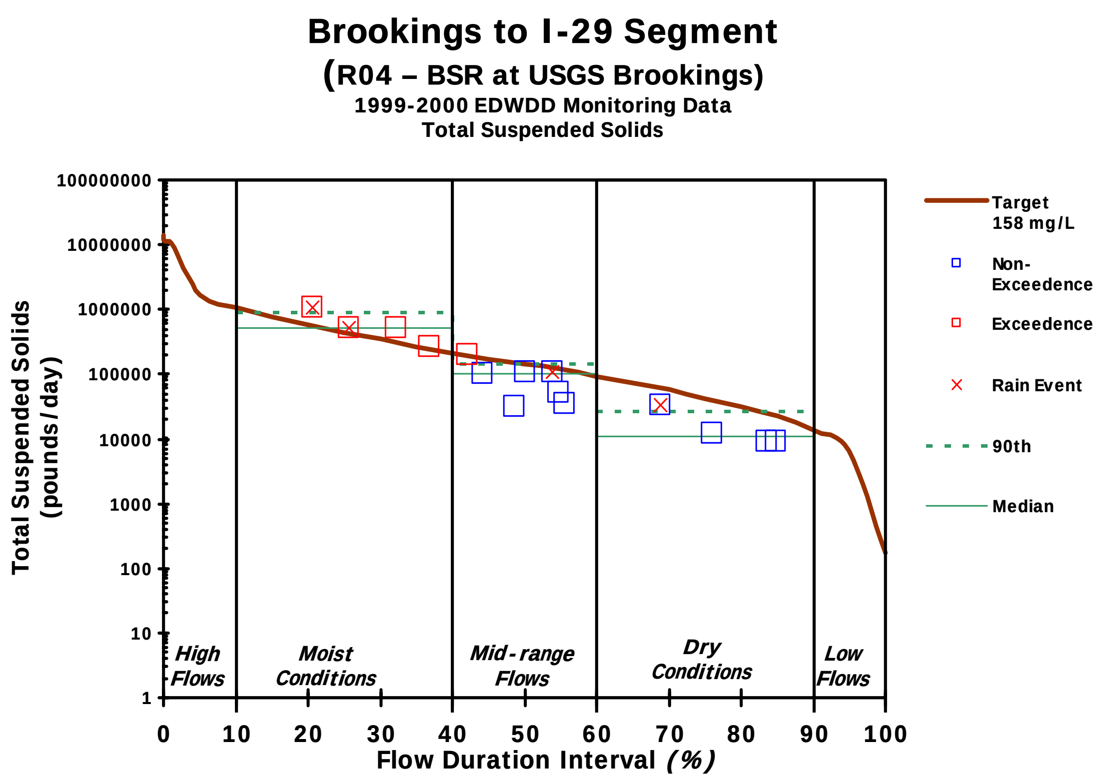


Figure 4. Flow Duration Interval for the Brookings to I-29 Watershed

Table 5. Sediment Target Loads for Flow

Flow Rank (percent)	cfs	Allowable Loads 158 mg/L TSS (pounds/day)	Flow Conditions
0.019	16220.00	1.38E+07	Peak
0.100	13870.00	1.18E+07	
0.274	13086.00	1.12E+07	
1	12600.00	1.07E+07	
5	2020.00	1.72E+06	
10	1270.00	1.08E+06	
15	916.90	7.82E+05	
20	696.00	5.93E+05	
25	526.50	4.49E+05	
30	404.80	3.45E+05	
35	315.10	2.69E+05	
40	248.40	2.12E+05	
45	200.00	1.71E+05	
50	170.00	1.45E+05	
55	140.00	1.19E+05	
60	110.00	9.38E+04	
65	87.00	7.42E+04	
70	68.00	5.80E+04	
75	50.00	4.26E+04	
80	37.00	3.15E+04	
85	26.00	2.22E+04	
90	16.00	1.36E+04	
95	7.50	6.39E+03	
100	0.20	1.71E+02	Low

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as pounds/day) High	Moist	Mid-Range	Dry	Low
SD-BS-R-Big_Sioux_06		TMDL	1.72E+06	4.49E+05	1.45E+05	4.26E+04	6.39E+03
		10% MOS	1.72E+05	4.49E+04	1.45E+04	4.26E+03	6.39E+02
		Total Allocations	1.55E+06	4.04E+05	1.30E+05	3.84E+04	5.75E+03
		LA	1.53E+06	3.95E+05	1.24E+05	3.32E+04	1.41E+03
	Brookings (WWTP)	WLA	2.25E+03	2.25E+03	2.25E+03	2.25E+03	2.25E+03
	Vera Sun (WWTP)	WLA	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03
	Aurora (WWTP)	WLA	1.84E+02	1.84E+02	1.84E+02	1.84E+02	1.84E+02
	White (WWTP)	WLA	1.06E+02	1.06E+02	1.06E+02	1.06E+02	1.06E+02
	SDSU (WWTP)	WLA	**0**	**0**	**0-**	**0**	**0**
	Brookings (MS4/P2)	WLA	1.10E+04	4.82E+03	2.00E+03	8.00E+02	0
		Background	3.07E+04	7.90E+03	2.48E+03	6.64E+02	2.82E+01
		Other NPS	1.50E+06	3.87E+05	1.22E+05	3.26E+04	1.38E+03

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the suspended solid standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 4.34×10^3 pounds if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet sediment standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the total suspended solids loading. Therefore, the "wasteload allocation" component is of no consequence, as indicated in the above TMDL.

A separate WLA for each flowzone was calculated for the NPDES-regulated storm water discharge from the City of Brookings. The stormwater contribution from the City of Brookings will be implemented through the storm water general permit. Sediment reductions necessary to meet the TMDL (19% reduction under moist conditions) will target nonpoint sources outlined in the LA section.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute sediment at rates above natural background. This includes cropland, pastureland, bed/bank erosion, and residential areas.

Predictions of sediment reduction were calculated using the SDM. This model shows reductions based on land management units (See Figure 39 in the Assessment Report). Table 6 shows sediment loads during a two-year rain event and the achievable reductions using buffers and conservation tillage. Figure 5 shows the locations of the targeted LMUs within the watershed.

Table 6. Sediment Loading by LMU for a Two Year Rain Event and Achievable Reductions

LMU	2 Year Rain Event (tons)	% Decrease with Stream Buffer	% Decrease With No Tillage	Decrease with Combination Buffer & No Tillage
R1	12707	3%	71%	72%
R2	107	1%	69%	70%
R3	4654	9%	70%	73%
R4	787	15%	71%	75%
C	1729	7%	71%	73%
B	554	19%	71%	77%
F	6	11%	71%	74%
L	276	0%	71%	71%
N	207	1%	71%	71%
MM		no drainage output		

Any remaining excess sediment is likely from bed and bank erosion. In which case, stream bank stabilization has shown to improve sediment reduction by 75-100 percent.

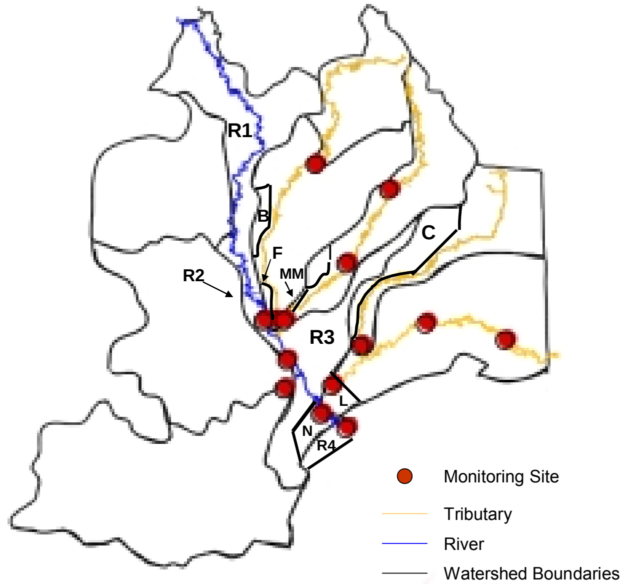


Figure 5. LMUs of the Brookings to I-29 Watershed

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. The ambient water quality from the SD DENR, were compared to historic precipitation data. The four Big Sioux River sites (R01-R04) are not meeting the water quality criteria for TSS. Of the samples taken that were exceeding the standard, 43 percent at R01, 33 percent at R02, 25 percent at R03, and 40 percent at R04 were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity; in this case 10 percent, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

Violations of the ≤ 158 mg/L standard for TSS occurred throughout the summer months of May-August in this segment of the Big Sioux River. This is the result of seasonal precipitation which causes additional particles to be carried into the river.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameters of total solids and total suspended solids. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Big Sioux River Segment – Brookings to I-29 TMDL.

Implementation Plan

The East Dakota Water Development District is working with the City of Sioux Falls and various stakeholders to initiate an implementation project, which is estimated to begin in 2005. It is expected that a local sponsor will request Section 319 funding for project assistance during early 2005.

Brookings to I-29 Segment Total Suspended Solids Exceedences

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	TSS (mg/L)	TSS Load (pounds/day)
R04	05/19/00	1015	672	0.2059	20.59	299	1.08E+06
R04	07/14/00	1130	360	0.3218	32.18	260	5.05E+05
R04	06/02/00	930	512	0.2567	25.67	184	5.08E+05
R04	07/27/99	1715	292	0.3676	36.76	168	2.65E+05
R04	08/10/99	1015	223	0.421	42.1	166	2.00E+05

Appendix TT.
TMDL – I-29 to Near Dell Rapids (TSS)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Total Suspended Solids)

for the

Big Sioux River
(I-29 to near Dell Rapids)

(HUC 10170203)

Moody and Minnehaha Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

I-29 to near Dell Rapids Total Maximum Daily Load

Waterbody Type:	River Segment
Assessment Unit ID:	SD-BS-R-Big_Sioux_07
303(d) Listing Parameter:	Suspended Solids
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Domestic Water Supply Limited Contact Recreation Immersion Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Segment:	61.5 miles
Size of Watershed:	314,744 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models including Flow Duration Interval Zones and Sediment Delivery Model (SDM)
Location:	HUC Code: 10170203
Goal:	Full Support of the Waterwater Semi-permanent Fish-Life Propogation Beneficial Use
Target:	≤ 158 mg/L of total suspended solids (any one sample)

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The section of the Big Sioux River from I-29 to near Dell Rapids is a 61.5 mile segment with a watershed of approximately 314,744 acres, which includes LMUs R5, R6, R7, R8, 11, 12, 13, 14, P, Q, R, M, T, S, U, X, W, and OO. The segment is located within the Big Sioux River Basin (HUC 10170203) stretching across Moody County to the north-central part of Minnehaha County in South Dakota. The watershed of this segment lies within Brookings, Moody, Lake, and Minnehaha Counties as shown by the shaded region in Figure 1. This segment is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

This segment is influenced by the major tributaries of Spring Creek, Flandreau Creek, Jack Moore Creek, and Bachelor Creek. This segment was identified in the 2004 South Dakota 303(d) Waterbody List as not supporting for its beneficial use warmwater semi-permanent fish life propagation, due to excessive suspended solids. However, it was listed as full support of all uses in the 2006 303(d) Waterbody list. Furthermore, the Central Big Sioux River Watershed Assessment Project found this segment is not meeting the water quality criteria for total suspended solids. Appendix B of the Assessment Report summarizes the data collected during the period of July 1999 to October 2000.

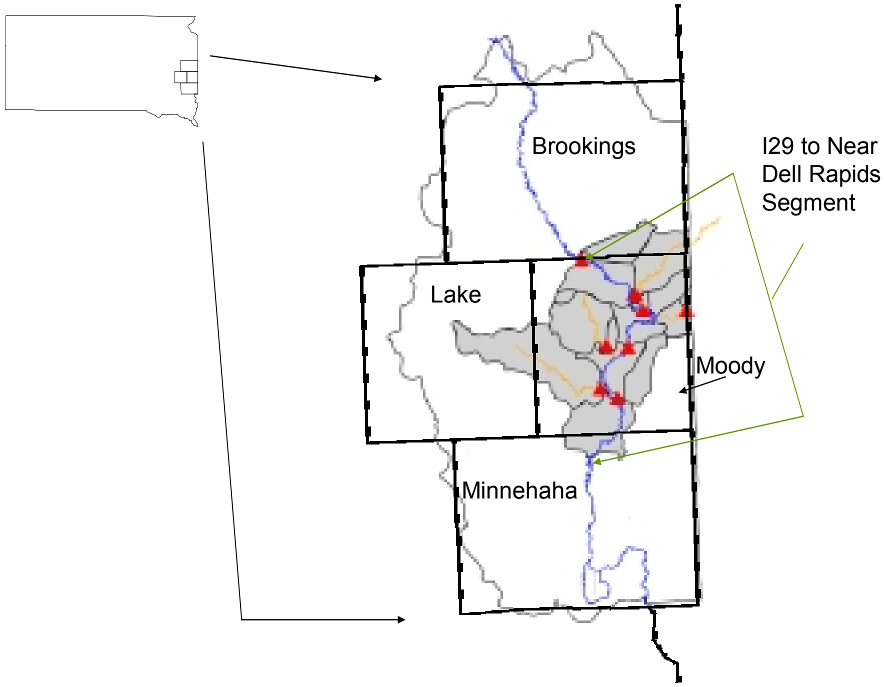


Figure 1. Location of the I-29 to Near Dell Rapids Segment and its Watershed in South Dakota

Problem Identification

The I-29 to Near Dell Rapids Segment is a small portion of the Big Sioux River, starting at monitoring site R04 and ending at monitoring site R08. The watershed area shown in Figure 2 drains approximately 96 percent grass/grazing land and cropland acres. This includes the receiving waters of Spring Creek (T11), Flandreau Creek (T12), Jack Moore Creek (T13), and Bachelor Creek (T14). The municipalities of Flandreau, Egan, Trent, Wentworth, Colman, Elkton, and Dell Rapids are located in this area.

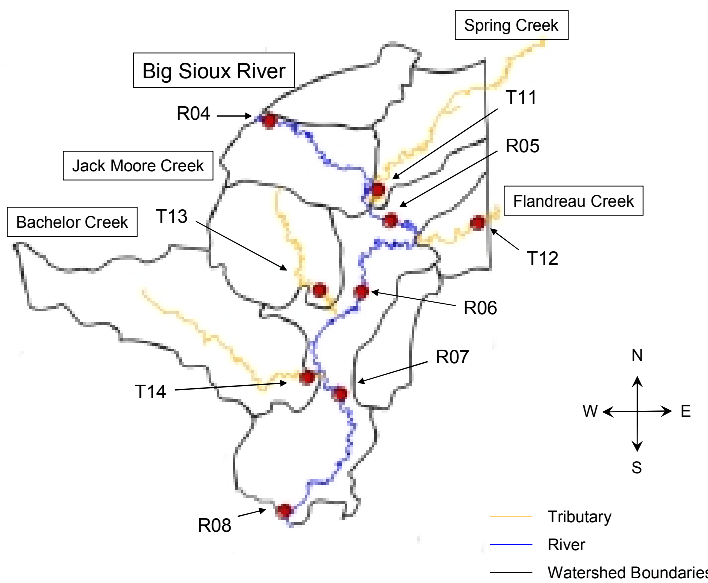


Figure 2. Big Sioux River Segment (I-29 to Near Dell Rapids) Watershed

The river segment between I-29 to near Dell Rapids (R04 to R08) was found to carry excessive sediment which degrades water quality. This segment of the Big Sioux River is considered impaired because more than 10 percent of the values (of more than 20 samples) exceeded the numeric criteria of ≤ 158 mg/L of total suspended solids per grab sample.

Five project monitoring locations (R4-R8) were set up on this segment of the Big Sioux River, and two DENR ambient water quality monitoring sites (BS18 and WQM3) coincided with two of the project sites. A total of 152 water quality samples were taken from these monitoring locations on the Big Sioux River. Of these 152 samples, 14 percent were violating water quality standards (Table 1). This 14 percent indicates that this segment is not meeting the water quality criteria for beneficial use (5) Warmwater Semi-permanent Fish Life Propagation. The excess sediment is believed to be coming from cropland runoff and bed/bank erosion.

Table 1. Summary of Total Suspended Solids Data for the I-29 to Dell Rapids Segment

Parameter Causing Impairment	Number of Samples	Percent of Samples >158 mg/L	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
TSS	152	13.8	0	474

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

The Big Sioux River segment from I-29 to Near Dell Rapids has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Domestic water supply
- Warmwater semi-permanent fish propagation
- Immersion recreation*
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

* Applies to R08 only

The tributaries flowing into this segment of the Big Sioux River have been assigned a range of beneficial uses as shown by the shaded areas in Table 2.

Table 2. Monitoring Sites and Their Beneficial Use Classification

	Tributaries			
Creek Name	Spring	Flandreau	Jack Moore	Bachelor
Beneficial Uses	T11	T12	T13	T14
Warmwater Semi-permanent Fish Life Propagation				
Warmwater Marginal Fish Life Propagation				
Immersion Recreation				
Limited Contact Recreation				
Fish & Wildlife Propagation, Recreation & Stock Watering				
Irrigation				

Individual parameters determine the support of beneficial uses. This segment experiences in-stream total suspended solid loading from bed and bank erosion and also external total suspended solid loading from its watershed. This segment is identified in both the 1998 and 2002 South Dakota Waterbody List as not supporting its warmwater semi-permanent fish life propagation beneficial use. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state.

To assess the status of the beneficial uses for this river segment, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Water samples from both the East Dakota Water Development District and the SD DENR ambient water quality monitoring program were utilized. The I-29 to Near Dell Rapids Segment of the Big Sioux River is currently assigned a numeric standard of ≤ 158 mg/L for TSS. Assessment monitoring indicates that there is a 14 percent exceedence in TSS during high flow conditions. Excessive TSS can decrease water clarity and increase water temperatures. Due to its adsorbing quality, sediment can also carry nutrients, such as phosphorus. This excess in sediment can have adverse affects on fish and other aquatic life. Theoretically, sediment accumulates as it moves downstream. Therefore, the loading at the most downstream monitoring site (R08) determined the reductions required for this creek.

A flow duration interval with hydrologic zones approach was used to assess this river segment. This methodology, developed by Dr. Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

The most downstream monitoring location (R08) was used to assess this stream using the flow duration interval method. Of the 55 water samples collected at this location, four (or seven percent) violated the water quality standards for total suspended solids. Although this site is fully supporting of its beneficial uses based solely on the grab samples at the downstream site, the flow duration interval indicates this monitoring site has problems with sediment during high flows. Additionally, the combination of grab samples from all monitoring locations on this river segment shows a 14 percent violation rate of the water quality standards. Therefore, the I-29 to Near Dell Rapids segment does not currently support its assigned Warmwater Semi-permanent Fish Life Propagation beneficial use

Each of the tributaries entering this segment was assessed for their level of sediment contribution to this segment. All four tributaries are currently supporting for warmwater marginal fish propagation at their current numeric standard of ≤ 263 mg/L (See Analysis and Summary Section of Assessment Report). When a more stringent standard of ≤ 158 mg/L is applied to each of these tributaries, they are fully supporting of beneficial use warmwater semi-permanent fish life propagation and do not require reductions in sediment. Therefore, improvement to water quality in the fore mentioned tributaries is unnecessary. Focus should be on the immediate area of the Big Sioux River.

Water quality violations seem to be a problem in the northern area (R04 and R05) of this segment. A targeted reduction towards higher flow conditions would improve sediment levels of the I-29 to Near Dell Rapids segment of the Big Sioux River to an acceptable daily load, with few violations of water quality and full support of its beneficial uses. Additionally, reductions in sediment to the segment directly north (Brookings to I-29 segment) would improve the sediment levels of this segment and ultimately reduce the grab sample violations.

Pollutant Assessment

Point Sources

There are eight NPDES facilities located within this watershed (Table 4). Total contribution from these facilities during the study period was insignificant, at >0.007 percent. Calculations used total kg from all the facilities divided by total kg from Site R08. The potential load from the facilities is shown in Table 3.

Table 3. NPDES Facilities.

Facility Name	**Permit Number**	**TSS** lbs/day
Colman	SD0022551	923.8
Dell Rapids	SD0022101	1,427.4
Egan	SD0022462	60.0
Elkton	SD0020788	1,205.5
Flandreau	SD0021831	2,753.2
T & R Electric	SD0025437	811.2
Trent	SD0020265	0
Wentworth	SD0026204	0

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of total suspended solids include loadings from surface runoff, bed and bank erosion, cropland erosion, construction erosion, and cropland erosion. Figure 3 depicts the flow of water in the watershed. Analysis of the sediment loadings from north to south indicates increased exceedences in sediment at Sites R04 and R05 in comparison to the more downstream monitoring sites (R06, R07, and R08). Based on grab sample data, neither R04 nor R05 is supporting the warmwater semi-permanent fish life propagation beneficial use. The increased loading at Sites R04 and R05 may indicate that this segment is being affected by the upstream segment of the Big Sioux River. This is the Brookings to I-29 segment, which is also listed for TSS impairment and TMDL development.

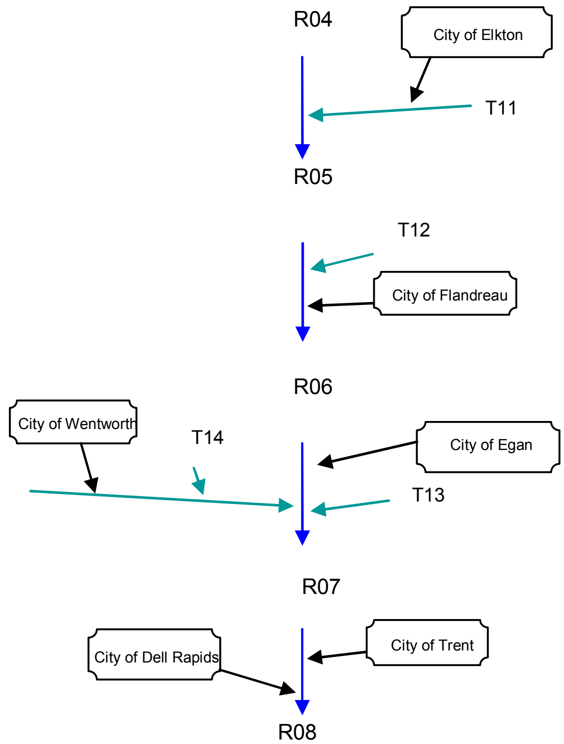


Figure 3. Water flow and estimated reductions in the watershed

Linkage Analysis

Water quality data was collected at five project sites (R04-R08), including two DENR ambient water quality monitoring locations, and four tributary sites (T11-T14). Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10 percent of the samples according to South Dakota's EPA approved Non-Point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Sediment Delivery Model (SDM) was used to define critical non-point source (NPS) pollution cells within the watershed (those with high sediment) and estimate the effective percent reduction needed in the watershed by adding various Best Management Practices (BMPs). See the Modeling and Results section of the final report for a complete summary of the results. The SDM was used to predict sediment loadings during 2, 5, 10, and 20 year (24 hour) rainfall events (Appendix Y, Assessment Report). Then best management practices, such as stream buffers and tillage practices, were applied to find the best achievable percent reductions (Appendix Z, Assessment Report).

The Flow Duration Interval Zone method calculates total suspended solids loading, (concentration) × (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of sediment for the I-29 to Near Dell Rapids segment of the Big Sioux River, the range of flows from the monitoring location were divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-range (40-60), Dry (60-90), and Low (90-100). Excessive sediment loadings are occurring during the high flow conditions. Flow duration intervals were calculated using the following equation:

$$(\text{flow}) \times (\text{conversion factor}) \times (\text{state criteria}) = \text{quantity/day or daily load}$$

This curve represents the threshold of the load. As seen in Figure 4, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Attachment 1 contains detailed exceedence information). Table 4 depicts the allowable sediment load during the study for peak flow, low flow, and 5th percentile increments in flow.

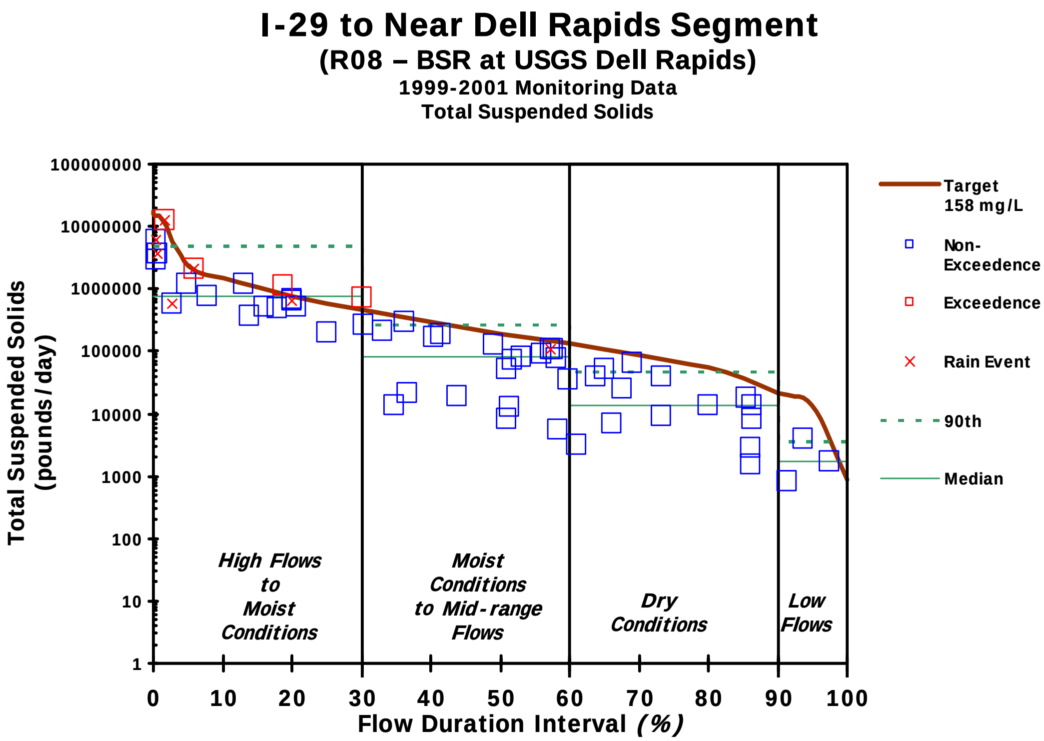


Figure 4. Flow Duration Interval for the I-29 to Near Dell Rapids Watershed

Table 4. Sediment Target Loads for Flow

Flow Rank (percent)	cfs	Allowable Loads 158 mg/L TSS (pounds/day)	Flow Conditions
0.019	21248.40	1.81E+07	Peak
0.100	18250.00	1.56E+07	
0.274	17121.00	1.46E+07	
1	16500.00	1.41E+07	
5	2816.00	2.40E+06	
10	1750.00	1.49E+06	
15	1260.00	1.07E+06	
20	896.40	7.64E+05	
25	684.00	5.83E+05	
30	540.00	4.60E+05	
35	425.00	3.62E+05	
40	345.00	2.94E+05	
45	280.00	2.39E+05	
50	227.00	1.94E+05	
55	191.00	1.63E+05	
60	160.00	1.36E+05	
65	125.00	1.07E+05	
70	100.00	8.53E+04	
75	79.00	6.74E+04	
80	63.00	5.37E+04	
85	43.20	3.68E+04	
90	25.00	2.13E+04	
95	16.00	1.36E+04	
100	1.00	8.53E+02	Low

TMDL Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as pounds/day) High	Moist	Mid-Range	Dry	Low
SD-BS-R-Big_Sioux_07		TMDL	2.40E+06	5.83E+05	1.94E+05	6.74E+04	1.36E+04
		10% MOS	2.40E+05	5.83E+04	1.94E+04	6.74E+03	1.36E+03
		Total Allocations	2.16E+06	5.25E+05	1.74E+05	6.06E+04	1.23E+04
		LA	2.15E+06	5.18E+05	1.67E+05	5.34E+04	5.10E+03
	Colman (WWTF)	WLA	9.24E+02	9.24E+02	9.24E+02	9.24E+02	9.24E+02
	Dell Rapids (WWTF)	WLA	1.43E+03	1.43E+03	1.43E+03	1.43E+03	1.43E+03
	Egan (WWTF)	WLA	6.00E+01	6.00E+01	6.00E+01	6.00E+01	6.00E+01
	Elkton (WWTF)	WLA	1.21E+03	1.21E+03	1.21E+03	1.21E+03	1.21E+03
	Flandreau (WWTF)	WLA	2.75E+03	2.75E+03	2.75E+03	2.75E+03	2.75E+03
	T&R Electric (WWTF)	WLA	8.11E+02	8.11E+02	8.11E+02	8.11E+02	8.11E+02
	Trent (WWTF)	WLA	0	0	0	0	0
	Wentworth (WWTF)	WLA	0	0	0	0	0
		Background	4.31E+04	1.04E+04	3.34E+03	1.07E+03	1.02E+02
		Other NPS	2.11E+06	5.07E+05	1.64E+05	5.24E+04	4.99E+03

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the suspended solid standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 7.18×10^3 pounds if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet sediment standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the total suspended solids loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute sediment at rates above natural background. This includes cropland, pastureland, bed/bank erosion, and residential areas.

Predictions of sediment reduction were calculated using the SDM. This model shows reductions based on land management units (See Figure 39 in the Assessment Report). Table 5 shows sediment loads during a two year rain event and the achievable reductions using buffers and conservation tillage. Figure 5 shows the locations of the targeted LMUs within the watershed.

Table 5. Sediment Loading by LMU for a Two-Year Rain Event and Achievable Reductions

LMU	2 Year Rain Event (tons)	% Decrease with Stream Buffer	% Decrease With No Tillage	Decrease with Combination Buffer & No Tillage
R5	237	0%	65%	65%
P	11395	6%	70%	72%
R	65	8%	69%	71%
M	7589	3%	71%	72%
R6	4203	6%	70%	72%
OO	5764	8%	71%	73%
T	3843	10%	71%	73%
S	457	36%	70%	80%
R7	5884	10%	71%	74%
U	1920	29%	71%	79%
X	34	8%	71%	71%
R8	18939	8%	71%	73%
W	9037	14%	71%	75%
12	438	2%	66%	71%

Any remaining excess sediment is likely from bed and bank erosion. In which case, stream bank stabilization has shown to improve sediment reduction by 75 to 100 percent.

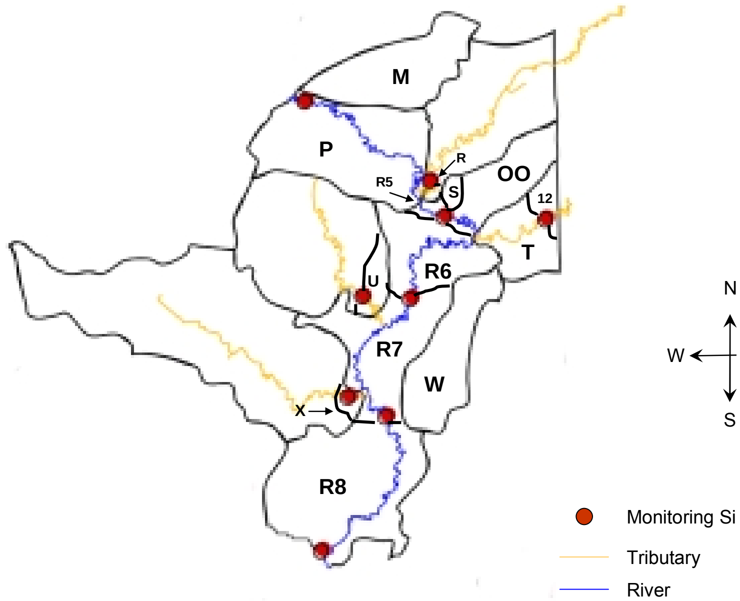


Figure 5. LMUs of the I-29 to Near Dell Rapids Watershed

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, runoff events were noted for East Dakota Water Development data on the sample date. Dates of the SD DENR ambient data were compared to historic precipitation data.

Two (R04 and R05) of the five Big Sioux River sites that make up this segment are not meeting the water quality criteria for TSS. Of the samples taken that were exceeding the standard, 40 percent at R04, 33 percent at R05, 67 percent at R06, 67 percent at R07, and 75 percent at R08 were during rain events. A lower percentage of violations at R04 and R05 during rain events, indicates a bed and bank problem in the northern area of the segment.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity; in this case 10 percent, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

Violations of the ≤ 158 mg/L standard for TSS occurred throughout the summer months of April-August on this segment of the Big Sioux River. Eleven of the 21 violations occurred during rain events in the months of April, May, and June. This seasonal precipitation can cause additional particles to be carried into the river.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameters of total solids and total suspended solids. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Big Sioux River Segment – I-29 to near Dell Rapids TMDL.

Implementation Plan

The East Dakota Water Development District is working with the City of Sioux Falls and various stakeholders to initiate an implementation project, which is estimated to begin in 2005. It is expected that a local sponsor will request Section 319 funding for project assistance during early 2005.

To guide implementation efforts the median concentration for each flowzone was used to calculate the existing condition. Using this baseline this segment requires reducing the pounds of total suspended solids per day, during high flows, by 14 percent (Table 6). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment.

Table 6. I-29 to Dell Rapids Total Suspended Solids Reductions

	Median	**High Flows (0-10)**	**Moist (10-40)**	**Mid-Range (40-60)**	**Dry (60-90)**	**Low Flows (90-100)**
	Median Concentration (pounds/day)	8.98E+02	7.22E+02	3.41E+02	1.73E+02	1.05E+02
X	Flow Median (cfs)	2816.00	684.00	227.00	79.00	16.00
=	Existing	2.53E+06	4.94E+05	7.75E+04	1.37E+04	1.68E+03
	Target Load (at 158 mg/L)	2.40E+06	5.83E+05	1.94E+05	6.74E+04	1.36E+04
	% Reduction w/MOS	14	0	0	0	0

Note: units are pounds/day

I-29 to Near Dell Rapids Segment Total Suspended Solids Exceedences

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	TSS (mg/L)	TSS Load (pounds/day)
R08	04/04/01	945	5000	0.0176	1.76	474	1.28E+07
WQM 3	05/24/00	unknown	536	0.3010	30.1	252	7.29E+05
WQM 3	06/16/99	unknown	970	0.1875	18.75	216	1.13E+06
R08	06/13/01	1030	2430	0.0598	5.98	164	2.15E+06

Appendix UU.
TMDL – Near Dell Rapids to Below Baltic
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for the

Big Sioux River
(Near Dell Rapids to Below Baltic)

(HUC 10170203)

Minnehaha County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Near Dell Rapids to Below Baltic Total Maximum Daily Load

Waterbody Type:	River Segment
Assessment Unit ID:	SD-BS-R-Big_Sioux_08
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Domestic Water Supply Limited Contact Recreation Immersion Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Segment:	18.7 miles
Size of Watershed:	59,376 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Immersion Recreation Beneficial Use during the months of May through September.
Target:	≤ 400 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The section of the Big Sioux River from Near Dell Rapids to Below Baltic is an 18.7 mile segment with a watershed of approximately 59,376 acres and includes LMUs R8 and AA. The segment is located within the Big Sioux River Basin (HUC 10170203) in the north-central part of Minnehaha County, South Dakota. The watershed of this segment lies within Moody and Minnehaha Counties as shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

Initially, the 1998 South Dakota 303(d) Waterbody List identified the segment from Near Dell Rapids to Below Baltic for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from statewide ambient monitoring data and the 1996 305(b) report. This segment was also identified in the 2004 and 2006 South Dakota 303(d) Waterbody List as not supporting for its beneficial use immersion recreation, due to excessive fecal coliform. Furthermore, the Central Big Sioux River Watershed Assessment Project identified this segment as impaired for fecal coliform bacteria.

ppendix B of the Assessment Report summarizes the data collected during the period of July 2000 to September 2001.

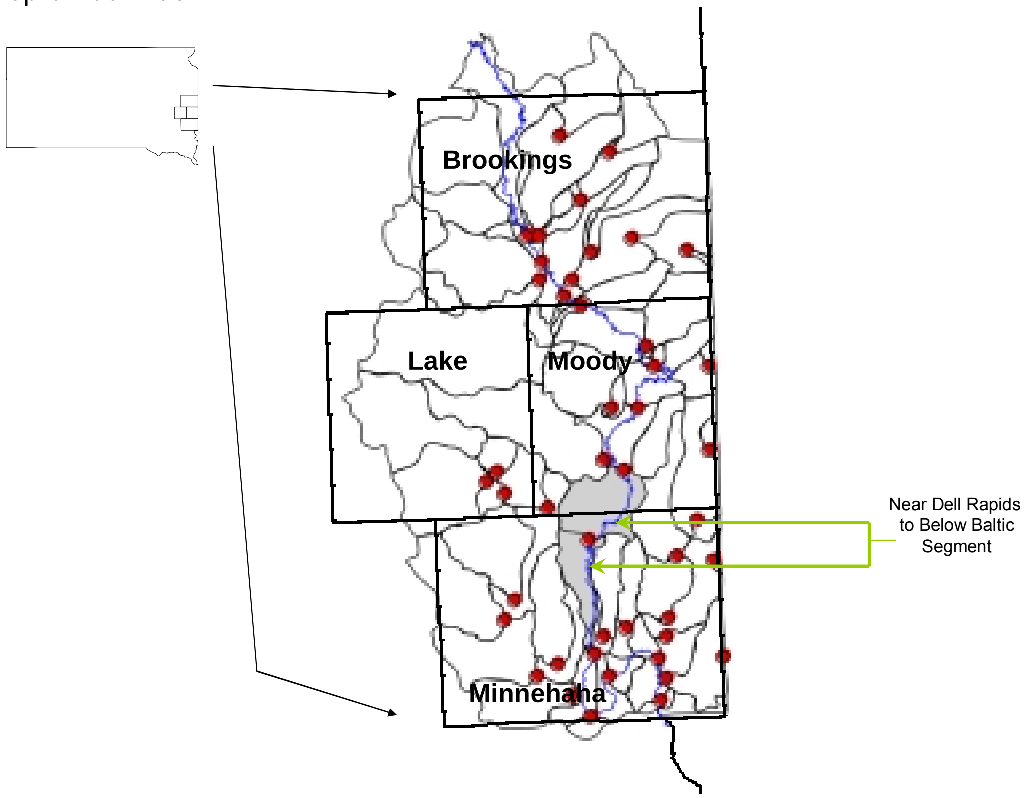


Figure 1. Location of the Near Dell Rapids to Below Baltic Segment and its Watershed in South Dakota.

Problem Identification

The Near Dell Rapids to Below Baltic Segment is a small portion of the Big Sioux River, starting just above monitoring site R08 and ending just below the city of Baltic. The watershed area shown in Figure 2 drains approximately 96 percent grass/grazing land and cropland acres. The municipalities of Dell Rapids and Baltic are located in this area.

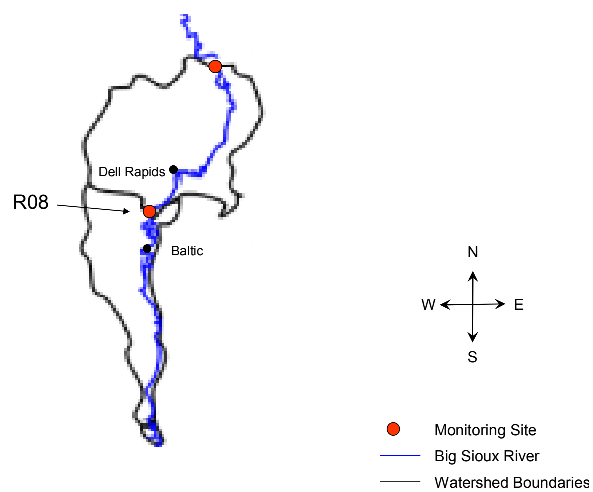


Figure 2. Big Sioux River Segment (Near Dell Rapids to Below Baltic) Watershed

The river segment Near Dell Rapids to Below Baltic (R08) was found to carry fecal coliform bacteria which degrades water quality. This segment is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 400 counts per 100 milliliters of fecal coliform bacteria. Table 1 displays the fecal coliform data collected from May 2000 to September 2000 and from May 2001 to September 2001.

Table 1. Summary of Fecal Coliform Data for the Near Dell Rapids to Below Baltic Segment

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 400 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	23	30.4	20	52,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

The Big Sioux River segment from Near Dell Rapids to Below Baltic has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Domestic water supply
- Warmwater semipermanent fish propagation
- Immersion recreation
- Limited contact recreation
- Fish and wildlife propagation, recreation and stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for immersion recreation and limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This segment experiences fecal coliform bacteria due to absent or poor riparian areas, stormwater runoff, and overflowing sewer systems. This segment is identified in both the 1998 and 2002 South Dakota Waterbody List as not supporting its immersion recreation beneficial use. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state.

To assess the status of the beneficial uses for this river segment, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Water samples from both the East Dakota Water Development District and the SD DENR ambient water quality monitoring program were utilized.

The Near Dell Rapids to Below Baltic segment was evaluated using the more stringent numeric standard of ≤ 400 cfu/100mL. Results show that this stream is not supporting its immersion recreation beneficial use. Analysis of its limited contact recreation beneficial use shows that at the ≤ 2,000 cfu/100mL numeric standard this segment is supporting of this beneficial use. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Dr. Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0 to 10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

One project monitoring location (R08) was setup at the midpoint of this segment, at the same location as a DENR ambient water quality monitoring site (WQM 3). Of the 23 water samples that were collected, seven (or 30 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this segment is currently not supporting its immersion recreation beneficial use (Appendix FF, Assessment Report).

Pollutant Assessment

Point Sources

There are three NPDES facilities located within this watershed (Table 3). NPDES facilities taken into consideration within this area include the City of Dell Rapids, the Town of Baltic, and LG Everist, Inc. Total contribution from these facilities during the study period was insignificant at 0.00004 percent. Calculations used total colonies from all the facilities divided by the total colonies at Site R08. The potential load from the facilities is shown in Table 2.

Table 2. NPDES Facilities.

Facility Name	Permit Number	# colonies/day
Dell Rapids	SD0022101	1.92E+10
Baltic	SD0022284	1.21E+10
LG Everist, Inc.	SD0000051	0

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities, including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling in this watershed are listed in Table 3.

Table 3. Livestock Distribution for Near Dell Rapids to Below Baltic Watershed

Livestock Distribution	Big Sioux River (R08)
Beef Cattle/Calves	9594
Hogs/Pigs	1283
Dairy Cattle	835
Horses	12
Sheep	202
Buffalo	----

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 4 shows that 96 percent of the area is grass or cropland. Urban/suburban areas would fall into the artificial category, which makes up approximately two percent of the watershed.

Table 4. Land Use in the Near Dell Rapids to Below Baltic Segment

LandUse	Percent	Acres
Water	0%	143
Trees	2%	913
Artificial	2%	888
Barren	0%	167
Grass	29%	17,334
LEP Cropland	59%	35,133
MEP Cropland	3%	1,853
HEP Cropland	5%	2,946

Linkage Analysis

Water quality data was collected at one project monitoring site (R08) which also coincided with one DENR ambient site (WQM 3) on the Big Sioux River. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this segment of the Big Sioux River, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this segment, the ranges or flow zones are High (0-10), Moist (10-40), Mid-Range (40-60), Dry (60-90) and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (See Attachment 1 for details). Table 5 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

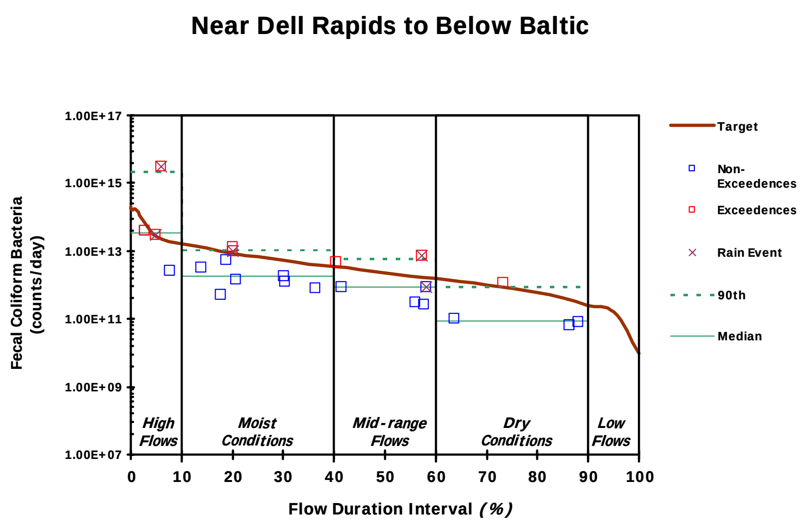


Figure 3. Flow Duration Interval for the Near Dell Rapids to Below Baltic Segment

Table 5. Fecal Coliform Target Loads for Flow

Flow Rank (percent)	cfs	Allowable Loads 400 cfu/100mL Fecal Coliform (counts/day)	Flow Conditions
0.019	21248.40	2.08E+14	Peak
0.100	18250.00	1.79E+14	
0.274	17121.00	1.68E+14	
1	16500.00	1.62E+14	
5	2816.00	2.76E+13	
10	1750.00	1.71E+13	
15	1260.00	1.23E+13	
20	896.40	8.77E+12	
25	684.00	6.69E+12	
30	540.00	5.29E+12	
35	425.00	4.16E+12	
40	345.00	3.38E+12	
45	280.00	2.74E+12	
50	227.00	2.22E+12	
55	191.00	1.87E+12	
60	160.00	1.57E+12	
65	125.00	1.22E+12	
70	100.00	9.79E+11	
75	79.00	7.73E+11	
80	63.00	6.17E+11	
85	43.20	4.23E+11	
90	25.00	2.45E+11	
95	16.00	1.57E+11	
100	1.00	9.79E+09	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 6 lists the 19 feedlots and their corresponding LMU, rating 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 6. Feedlot ratings ≥ 50 in the Near Dell Rapids to Below Baltic Watershed

LMU	Feedlot Rating
R8	50
R8	50
R8	52
R8	53
R8	56
R8	58
R8	58
R8	59
R8	62
R8	63
R8	63
R8	64
R8	65
R8	65
R8	66
R8	70
R8	73
R8	74
AA	89

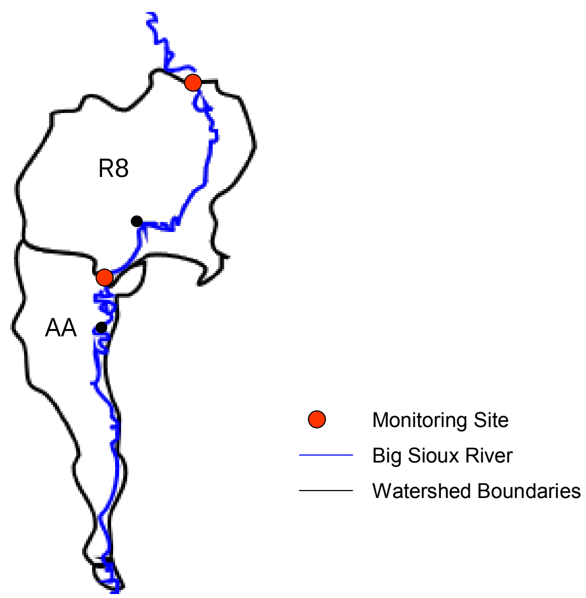


Figure 4. LMUs of the Near Dell Rapids to Below Baltic Watershed

TMDL Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)			
			High	**Moist**	**Mid-Range**	**Dry**
SD-BS-R-Big_Sioux_08		TMDL	2.76E+13	6.69E+12	2.22E+12	7.73E+11
		10% MOS	2.76E+12	6.69E+11	2.22E+11	7.73E+10
		Total Allocations	2.48E+13	6.02E+12	2.00E+12	6.96E+11
		LA	2.48E+13	5.99E+12	1.97E+12	6.64E+11
	Dell Rapids (WWTF)	WLA	1.92E+10	1.92E+10	1.92E+10	1.92E+10
	Baltic (WWTF)	WLA	1.21E+10	1.21E+10	1.21E+10	1.21E+10
	LG Everist, Inc. (SWDP)	WLA	0	0	0	0
		Background	4.96E+11	1.20E+11	3.93E+10	1.33E+10
		Other NPS	2.43E+13	5.87E+12	1.93E+12	6.51E+11

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 3.13×10^{10} fecal counts if all the facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this segment will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the "wasteload allocation" component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. The ambient water quality from the SD DENR, were compared to historic precipitation data. Monitoring site R08 on the Big Sioux River is not meeting the water quality criteria for fecal coliform bacteria. Of the seven samples that were exceeding the ≤ 400 cfu/100mL standard, four (or 57 percent) were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Big Sioux River Segment – Near Dell Rapids to Below Baltic TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and urban BMPs to reduce loads during runoff events.

To guide implementation efforts the median concentration for each flowzone was used to calculate the existing condition. Using this baseline, this segment requires reducing the fecal coliform counts per day by 29 percent during high flow conditions (Table 7). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median is used here as a starting point.

Table 7. Near Dell Rapids to Below Baltic Fecal Coliform Bacteria Reductions

	Median	High (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flow (90-100)
	Median Concentration (counts/day)	1.25E+10	2.69E+09	3.76E+09	1.14E+09	------
X	Flow Median (cfs)	2816	684	227	79	16
=	Existing	3.51E+13	1.84E+12	8.53E+11	9.00E+10	------
	Target Load (at 400 cfu/100mL)	2.76E+13	6.69E+12	2.22E+12	7.73E+11	1.57E+11
	% Reduction w/MOS	29	0	0	0	------
Note: units are counts/day						

Fecal Exceedences for the Near Dell Rapids to Below Baltic Segment

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
R08	06/13/01	1030	2430	0.0598	5.98	52000	3.09E+15
R08	07/11/00	1100	177	0.5731	57.31	1700	7.36E+12
R08	07/24/01	1120	897	0.2000	20.00	600	1.32E+13
R08	08/17/00	1215	85	0.7329	73.29	570	1.19E+12
WQM3	09/17/01	unknown	338	0.4049	40.49	550	4.55E+12
WQM3	07/24/01	unknown	897	0.2000	20.00	440	9.66E+12
WQM3	06/18/01	unknown	2850	0.0492	4.92	430	3.00E+13

Appendix VV.
TMDL – North Deer Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

North Deer Creek
(Near Bruce to Near Brookings Segment)

(HUC 10170202)

Brookings County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

North Deer Creek Total Maximum Daily Load

Waterbody Type:	Stream Segment
Assessment Unit ID:	SD-BS-R-NORTH_DEER_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Segment:	20.1 miles
Size of Watershed:	54,928 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170202
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

The Near Bruce to Near Brookings segment of North Deer Creek is a 20.1 mile stream segment with a watershed of approximately 54,928 acres and is a tributary to the Big Sioux River in central Brookings County, South Dakota. The watershed of this stream segment lies within Brookings County as shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1. North Deer Creek was not on the 2006 303(d) Waterbody list.

The Central Big Sioux River Watershed Assessment Project identified this segment of North Deer Creek, from monitoring site T01 to monitoring site T02, for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from monitoring data collected by the East Dakota Water Development District. North Deer Creek was not on any 303(d) State Waterbody lists prior to this assessment. Appendix B of the Assessment Report summarizes the data collected during the Central Big Sioux River Watershed Assessment Project from July 1999 to September 2000.

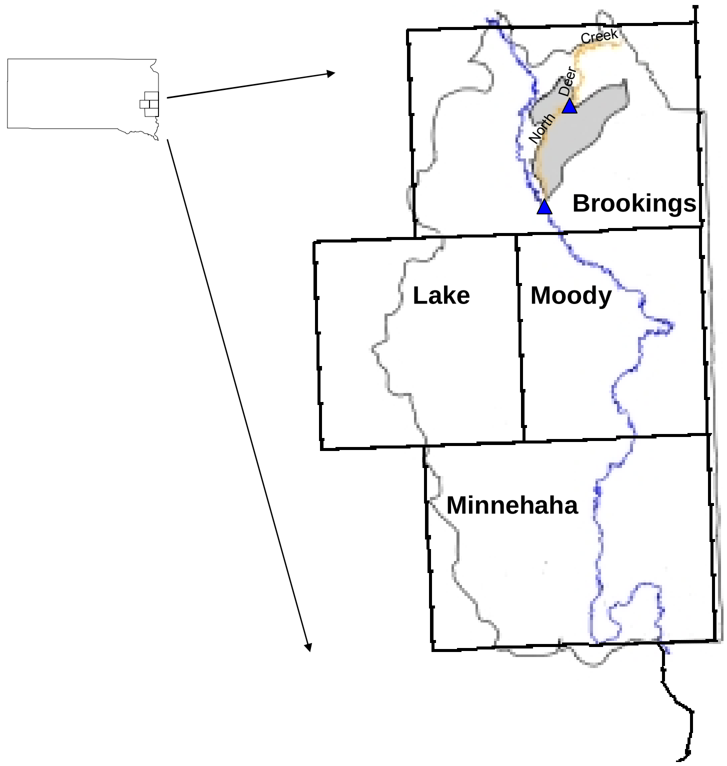


Figure 1. Location of the North Deer Creek Watershed in South Dakota

Problem Identification

The Near Bruce to Near Brookings Segment is a portion of North Deer Creek, starting at monitoring site T01 and ending at monitoring site T02. The watershed area shown in Figure 2 drains approximately 99 percent grass/grazing land and cropland acres. There are no municipalities located in this area.

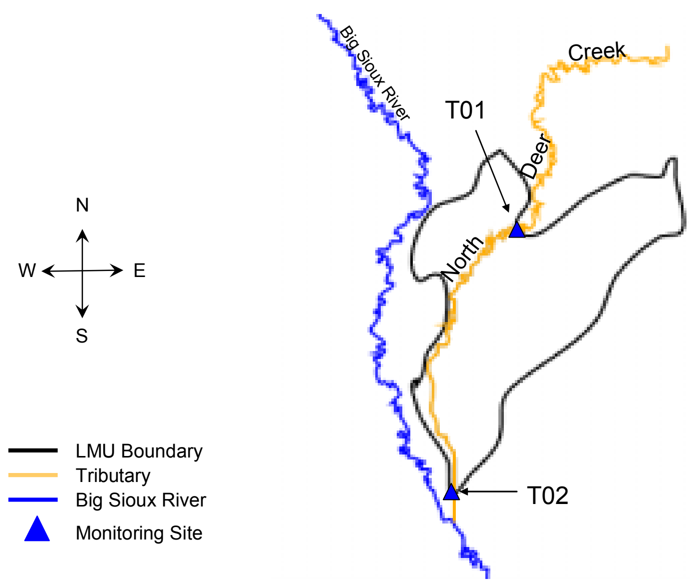


Figure 2. North Deer Creek Watershed

The North Deer Creek segment Near Bruce to Near Brookings (T02) was found to carry fecal coliform bacteria which degrades water quality. This segment is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters of fecal coliform bacteria. Table 1 displays the fecal coliform data collected from July 1999 to September 1999 and from May 2000 to September 2000.

Table 1. Summary of Fecal Coliform Data for North Deer Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	7	28.6	70	39,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

This segment of North Deer Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involves monitoring the levels of fecal coliform from May 1 though September 30. To assess the status of the beneficial uses for this stream segment, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. This segment experiences fecal coliform loading due to absent or poor riparian areas, pastured livestock, and manure/feedlot runoff.

North Deer Creek is currently assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Dr. Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach the following three hydrologic conditions were utilized: High to Mid-range Conditions (0-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

One monitoring location, T02, was setup on this segment of North Deer Creek. Of the seven water samples that were collected, two (or 28.6 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this segment is currently not supporting its limited contact recreation beneficial use (Appendix FF, Assessment Report).

Pollutant Assessment

Point Sources

There are no identified NPDES facilities within this watershed.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliform bacteria include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 2.

Table 2. Livestock Distribution for the North Deer Creek Watershed

Livestock Distribution	T02
Beef Cattle/Calves	4979
Hogs/Pigs	182
Dairy Cattle	285
Horses	--------
Buffalo	--------
Sheep	1525

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. Fecal coliform from failing septic systems may be absorbed in the soil and vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 3 shows that 99 percent of the area is grass or cropland.

Table 3. Landuse in the North Deer Creek Watershed

Landuse	Percent	acres
Water	0%	10
Trees	1%	527
Artificial	1%	396
Barren	0%	0
Grass	34%	18,747
LEP Cropland	63%	34,369
MEP Cropland	1%	626
HEP Cropland	1%	253

LEP= Low Erosion Potential
MEP= Medium Erosion Potential
HEP= High Erosion Potential

Linkage Analysis

Water quality data was collected at one monitoring site on North Deer Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this segment of the North Deer Creek, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. For this segment, the ranges or flow zones are High to Mid-Range (0-60), Dry Conditions (60-90), and Low Flows (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (See Attachment 1 for details). Table 4 depicts the allowable coliform bacteria load for peak flow, low flow, and 5th percentile increments in flow.

North Deer Creek Segment

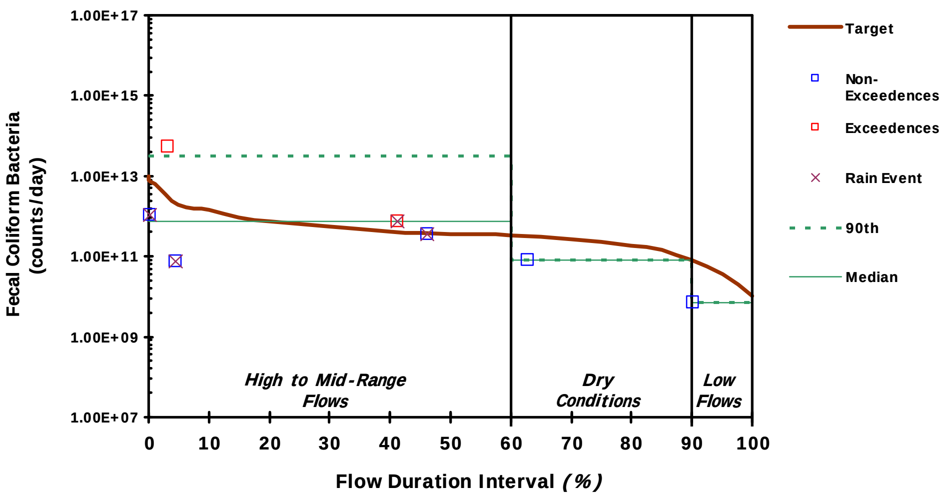


Figure 3. Flow Duration Interval for the North Deer Creek Segment

Table 4. Fecal Coliform Target Loads for Flow

		Allowable Loads 2000 cfu/100mL	
(percent)	cfs	Coliform	Conditions
0.019	197.10	9.65E+12	Peak
0.100	161.97	7.93E+12	
0.274	145.33	7.11E+12	
1	133.00	6.51E+12	
5	40.97	2.00E+12	
10	28.97	1.42E+12	
15	19.48	9.53E+11	
20	15.65	7.66E+11	
25	12.94	6.33E+11	
30	11.07	5.42E+11	
35	9.67	4.73E+11	
40	8.41	4.12E+11	
45	7.80	3.82E+11	
50	7.50	3.67E+11	
55	7.21	3.53E+11	
60	6.91	3.38E+11	
65	6.09	2.98E+11	
70	5.45	2.67E+11	
75	4.58	2.24E+11	
80	3.84	1.88E+11	
85	2.91	1.43E+11	
90	1.70	8.33E+10	
95	0.72	3.53E+10	
100	0.21	1.02E+10	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze current feedlots and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agriculture related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 5 lists the 12 feedlots that rated 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 5. Feedlot Ratings ≥ 50 for North Deer Creek Watershed

LMU	Feedlot Rating
2	52
2	53
2	56
2	56
2	61
2	62
2	62
2	67
2	68
2	69
2	83
2	64

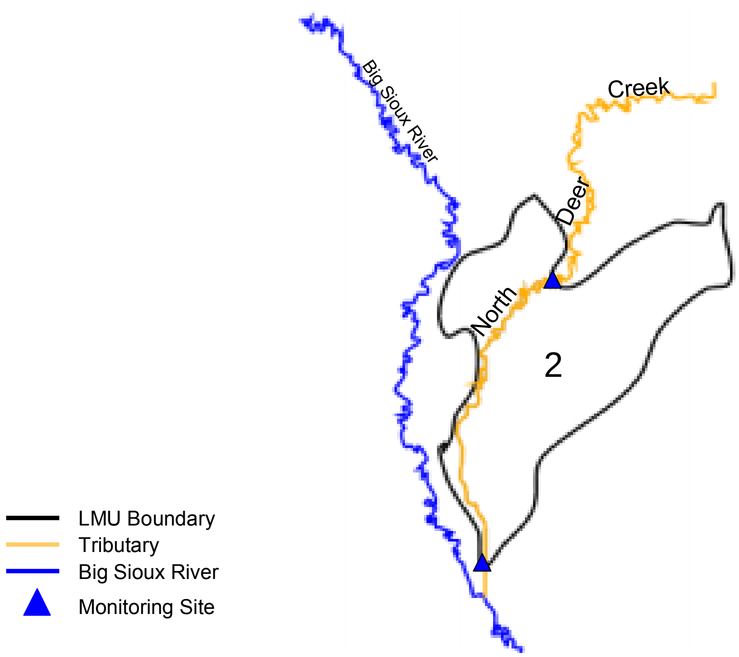


Figure 4. LMU of the Near Bruce to Near Brookings Watershed

TMDL Allocations

TMDL

Zone	TMDL			Point Source	Non-Point Source		
					100% =	2% +	98%
	TMDL	10% MOS	Total Allocations	WLA	LA	% Background	Other NPS
High/Moist	5.42E+11	5.42E+10	4.88E+11	0.00E+00	4.88E+11	9.76E+09	4.78E+11
Mid-Range	2.24E+11	2.24E+10	2.02E+11	0.00E+00	2.02E+11	4.04E+09	1.98E+11
Dry	3.53E+10	3.53E+09	3.18E+10	0.00E+00	3.18E+10	6.36E+08	3.12E+10
Note: units are counts/day							

Wasteload Allocations (WLAs)

There are no identified point sources in this watershed. Therefore, the “wasteload allocation” component of this TMDL will be zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources and is based on the flow duration interval approach. Since there are no WLAs within this watershed, load allocations from non-point sources account for the total target load. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Of the two samples collected at T02 that were exceeding the ≤ 2,000 cfu/100mL standard, one (or 50 percent) occurred during a rain event.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform bacteria loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the North Deer Creek Segment – Near Bruce to Near Brookings TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop and implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 34 percent during high to mid-range flow conditions (Table 7). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 7. North Deer Creek Fecal Coliform Bacteria Reductions

	Median	High to Mid-Range (0-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	6.79E+10	1.77E+10	9.81E+09
X	Flow Median (cfs)	11.07	4.58	0.75
=	Existing	7.52E+11	8.09E+10	7.36E+09
	Target Load (at 2,000 cfu/100mL)	5.42E+11	2.24E+11	3.53E+10
	% Reduction w/MOS	34	0	0

Note: units are counts/day

Fecal Exceedences for North Deer Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T02	07/12/00	1145	57.15	0.0119	1.19	39000	5.45E+13
T02	05/08/00	1030	8.09	0.2661	26.61	3800	7.52E+11

Appendix WW.
TMDL – Six Mile Creek
(Fecal Coliform Bacteria)

DRAFT

T0 be Submitted at a Later Date

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Six Mile Creek
(Near White to Near Brookings Segment)

(HUC 10170202)

Brookings County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

Six Mile Creek Total Maximum Daily Load

Waterbody Type:	Stream Segment
Assessment Unit ID:	SD-BS-R-SIXMILE_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation, Recreation and Stock Watering Irrigation
Length of Stream:	26.2 miles
Size of Watershed:	24,423 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170202
Goal:	Reduce the fecal coliform counts per day by 12 percent during high flows/moist conditions
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Six Mile Creek is a 26.2 mile stream segment with a watershed of approximately 24,423 acres (LMUs 4, 5, D, F, and MM) and is a tributary to the Big Sioux River in east-central Brookings County, South Dakota. The watershed of this stream is shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1. Six Mile Creek was not on the 2006 303(d) Waterbody list.

The Central Big Sioux River Watershed Assessment Project identified the Six Mile Creek segment from Near White to Near Brookings for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from monitoring data collected by the East Dakota Water Development District. Appendix B of the Assessment Report summarizes the data collected during the period of July 1999 to September 2000.

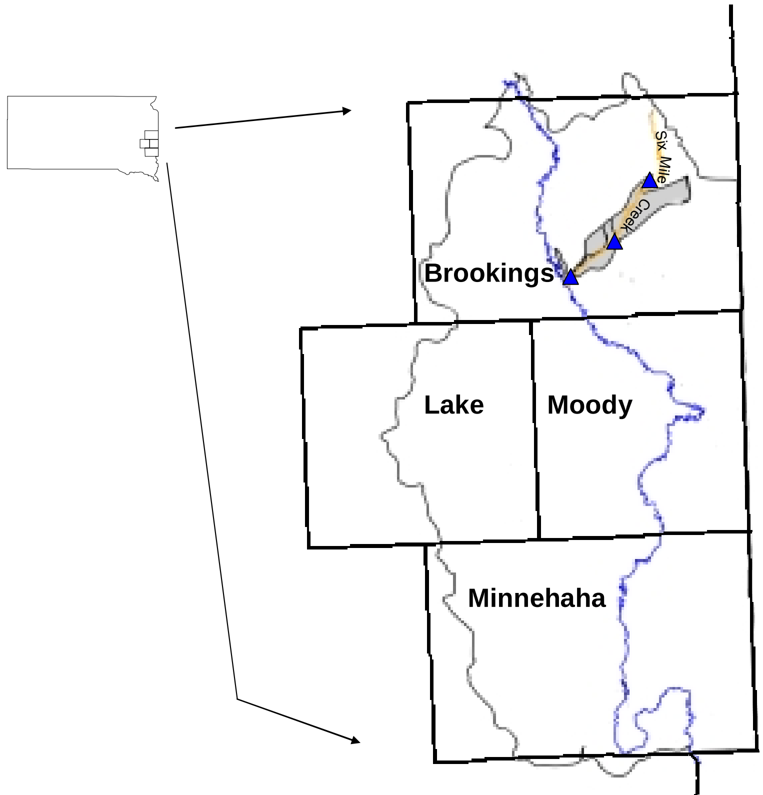


Figure 1. Location of the Six Mile Creek (Near White to Near Brookings) Watershed in South Dakota

Problem Identification

Six Mile Creek begins in northern Brookings County and enters the Big Sioux River in south-central Brookings County and includes monitoring sites T03, T04, and T05. The segment of concern is located between the City of White and the City of Brookings and includes monitoring sites T04 and T05. The watershed area shown in Figure 2 drains approximately 95 percent grass/grazing land and cropland acres. The municipalities of White and Brookings are located in this area.

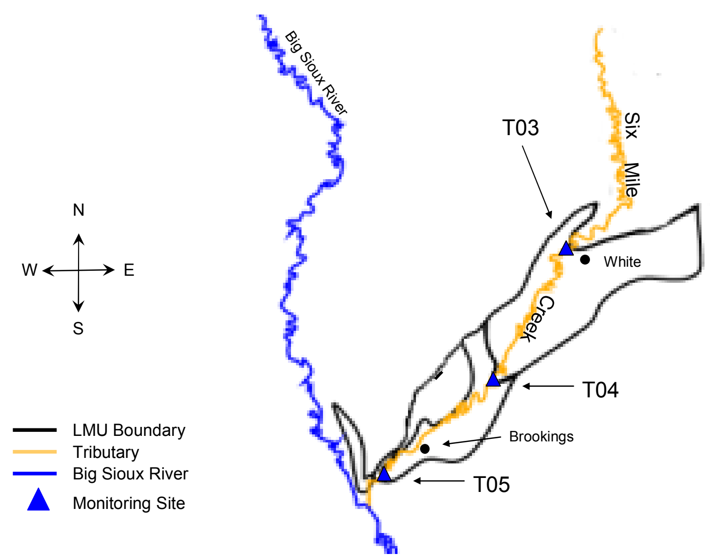


Figure 2. Six Mile Creek (Near White to Near Brookings) Watershed

Six Mile Creek (T04 and T05) was found to carry fecal coliform bacteria which degrades water quality. This segment of stream is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters for fecal coliform bacteria. This tributary requires reducing the fecal coliform counts per day by 12 percent during high flows/moist conditions. Table 1 displays the fecal coliform data collected from July 1999 to September 1999 and from May 2000 to September 2000.

Table 1. Summary of Fecal Coliform Data for the Six Mile Creek Segment

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	25	44	70	67,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Six Mile Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this tributary. These criteria must be maintained for the tributary to satisfy its assigned beneficial uses, which are listed in below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involves monitoring the levels of fecal coliform from May 1 though September 30. Six Mile Creek is identified as not supporting its limited contact recreation beneficial use. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. This tributary experiences fecal coliform loading due to absent or poor riparian areas, pastured livestock, manure, feedlot runoff, stormwater, and NPDES systems.

Six Mile Creek is currently assigned a numeric standard of ≤ 2,000 cfu/100mL (fecal coliform bacteria) for limited contact recreation. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Dr. Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach the following three hydrologic conditions were utilized: High Flows/Moist Conditions (0-40 percent), Mid-Range Flows/Dry Conditions (40-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

Two monitoring locations, T04 and T05, were setup on this segment of Six Mile Creek. Of the 25 water samples that were collected, 11 (or 44 percent) violated the water quality standards. Based on the water quality violations, Six Mile Creek is currently not supporting its limited contact recreation beneficial use (Appendix FF, Assessment Report). This segment requires reducing the fecal coliform counts per day by 12 percent during high flow/moist conditions (Table 2). Six Mile Creek flows into a segment of the Big Sioux River, which is currently in full support of the beneficial use limited contact recreation.

Table 2. Six Mile Creek Fecal Coliform Bacteria Reductions

	Median	High/Moist (0-40)	Mid-Range/Dry (40-90)	Low Flow (90-100)
	Median Concentration (counts/day)	5.06E+10	3.21E+10	------
X	Flow Median (cfs)	6.8	0.89	0.06
=	Existing	3.44E+11	2.86E+10	------
	Target Load (at 2,000 cfu/100mL)	3.33E+11	4.36E+10	2.94E+09
	% Reduction w/MOS	12	0	------

Note: units are counts/day

Pollutant Assessment

Point Sources

NPDES facilities taken into consideration within this segment of Six Mile Creek include South Dakota State University and the City of White (Table 3). Total contribution from these facilities during the study period was insignificant at 0.00006 percent. Calculations used total colonies from all the facilities divided by the total colonies at Site T04 (Site T04 was used because only the City of White discharged). The potential load from the facilities is shown in Table 3.

Table 3. NPDES Facilities.

Facility Name	Permit Number	# colonies/day
SDSU	SD0026832	-
White	SD0021636	2.13E+10

The City of Brookings is also covered for discharges associated with medium municipal separate storm sewer systems (Phase II - MS4) (NPDES Permit #: SDR41A003). The General Surface Water Discharge Permit for Small Municipal Separate Storm Sewer Systems in South Dakota contains requirements that are based on technology considerations, Best Management Practices (BMPs), and other conditions applicable to the types of storm water generated within and discharged from municipal systems.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 4.

Table 4. Livestock Distribution for the Six Mile Creek Watershed

Livestock Distribution	Six Mile Creek (T04-T05)
Beef Cattle/Calves	1691
Hogs/Pigs	50
Dairy Cattle	25
Horses	70
Buffalo	------
Sheep	90

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 5 shows that 95 percent of the area is grass or cropland. Urban areas would fall into the artificial category, which makes up approximately four percent of the watershed.

Table 5. Landuse in the Six Mile Creek Watershed.

LandUse	Percent	Acres
Water	0%	12
Trees	1%	283
Artificial	4%	977
Barren	0%	2
Grass	39%	9,635
LEP Cropland	53%	12,986
MEP Cropland	2%	386
HEP Cropland	1%	139

LEP = Low Erosion Potential

MEP = Medium Erosion Potential

Linkage Analysis

Water quality data was collected at two monitoring sites (T04 and T05) on the Six Mile Creek segment Near White to Near Brookings. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for the Six Mile Creek segment, the range of flows from the two monitoring locations were merged to form the duration interval curve and were then divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. For this stream, the ranges or flow zones are High/Moist (0-40), Mid-Range/Dry (40-90), and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (See Attachment 1 for details). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

Six Mile Creek
(Near White to Near Brookings)

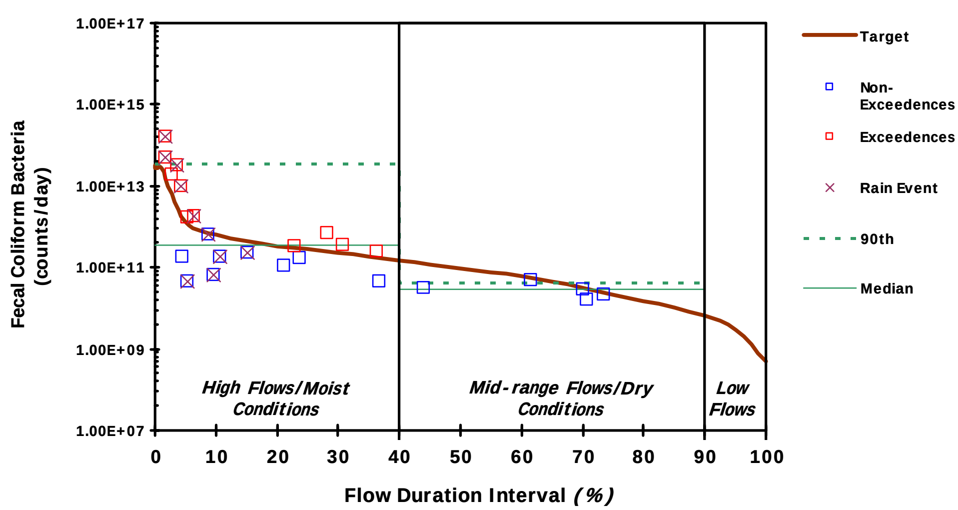


Figure 3. Flow Duration Interval for Six Mile Creek (Near White to Near Brookings Segment)

Table 6. Fecal Coliform Target Loads for Flow

Flow Rank (percent)	cfs	Allowable Loads 2000 cfu/100mL Coliform (counts/day)	Flow Conditions
0.019	657.44	3.22E+13	Peak
0.100	584.00	2.86E+13	
0.274	576.48	2.82E+13	
1	571.00	2.79E+13	
5	28.00	1.37E+12	
10	13.00	6.36E+11	
15	8.83	4.32E+11	
20	6.80	3.33E+11	
25	5.70	2.79E+11	
30	4.80	2.35E+11	
35	3.84	1.88E+11	
40	3.10	1.52E+11	
45	2.40	1.18E+11	
50	1.90	9.30E+10	
55	1.50	7.34E+10	
60	1.20	5.87E+10	
65	0.89	4.36E+10	
70	0.62	3.03E+10	
75	0.45	2.20E+10	
80	0.30	1.47E+10	
85	0.21	1.03E+10	
90	0.14	6.85E+09	
95	0.06	2.94E+09	
100	0.01	4.89E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze current feedlots and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agriculture related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 7 lists the feedlots for each LMU within this watershed that rated 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 4. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 7. Feedlot Ratings ≥ 50 for the Six Mile Creek Watershed

LMU	Feedlot Rating
4	50
4	53
4	56
4	56
4	57
4	59
4	61
4	67
D	55

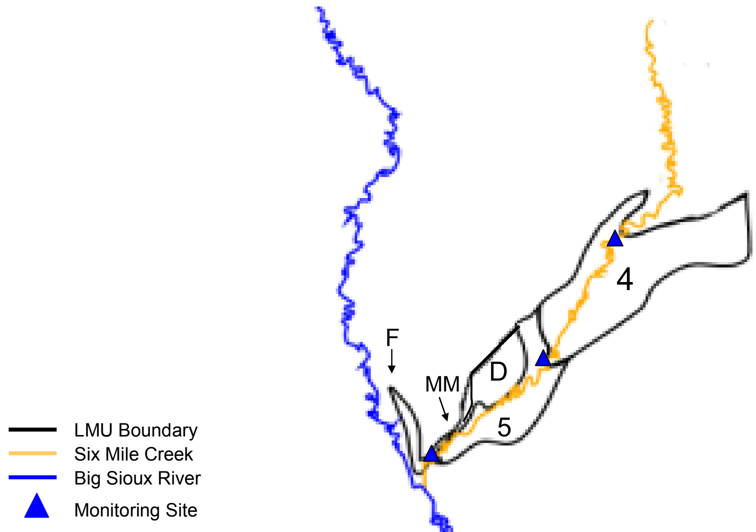


Figure 4. LMUs of the Six Mile Creek (Near White to Near Brookings Watershed)

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)	
			High/Moist	**Mid-Range/Dry**
SD-BS-R-SIXMILE_01		TMDL	3.33E+11	4.36E+10
		10% MOS	3.33E+10	4.36E+09
		Total Allocations	3.00E+11	3.92E+10
		LA	2.39E+11	1.54E+10
	SDSU (SWDP)	WLA	-	-
	White (WWTF)	WLA	2.13E+10	2.13E+10
	Brookings (MS4/P2)	WLA	3.90E+10	2.51E+09
		Background	4.79E+09	3.09E+08
		Other NPS	2.35E+11	1.51E+10

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment is approximately 2.13×10^{10} fecal counts if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this segment will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

A separate WLA for each flowzone was calculated for the NPDES-regulated storm water discharge from the City of Brookings to Six Mile Creek. The stormwater contribution from the City of Brookings will be implemented through the storm water general permit. Fecal Coliform reductions necessary to meet the TMDL (12% reduction under High/Moist conditions) will target nonpoint sources outlined in the LA section.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, a 12 percent reduction is needed from non-point sources during high flow/mid-range conditions (refer to Figure 3), as shown in Table 2.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Of the 11 samples that were exceeding the ≤ 2,000 cfu/100mL standard, five (or 46 percent) occurred during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Six Mile Creek – Near White to Near Brookings TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop and implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and urban BMPs to reduce loads during runoff events.

Fecal Exceedences for the Six Mile Creek Segment

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T04	05/17/00	1830	98.50	0.0174	1.74	67000	1.61E+14
T05	05/11/00	845	43.46	0.0361	3.61	30000	3.19E+13
T05	05/17/00	1700	104.21	0.0162	1.62	20000	5.10E+13
T04	07/12/00	1015	60.10	0.0276	2.76	13000	1.91E+13
T05	08/30/99	930	35.35	0.0437	4.37	11000	9.51E+12
T04	08/30/99	845	5.23	0.2817	28.17	5600	7.16E+11
T05	05/16/00	1115	20.52	0.0633	6.33	3700	1.86E+12
T04	09/13/99	800	4.69	0.3079	30.79	3100	3.56E+11
T04	08/09/99	1130	3.66	0.3642	36.42	2700	2.42E+11
T05	07/12/00	1130	25.60	0.0534	5.34	2600	1.63E+12
T04	06/13/00	1400	6.16	0.2289	22.89	2200	3.32E+11

Appendix XX.
TMDL – Spring Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Spring Creek
(within South Dakota)

(HUC 10170203)

Brookings and Moody Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Spring Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-SPRING_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation, Recreation and Stock Watering Irrigation
Length of Stream:	30.8 miles (within South Dakota)
Size of Watershed:	31,743 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective
The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction
Spring Creek is a 30.8 mile portion of tributary with a watershed of approximately 31,743 acres (within South Dakota), and includes LMUs 11 and R. Spring Creek is a tributary to the Big Sioux River in north-eastern Moody County, SD. The watershed within South Dakota, lies in south-eastern Brookings County and north-eastern Moody County, as shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. Approximately 10 percent of this creek's watershed also lies within Minnesota. The entire study area for this project is outlined in Figure 1. Spring Creek was not on the 2006 303(d) Waterbody list.

The Central Big Sioux River Watershed Assessment Project identified Spring Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Spring Creek was not on any 303(d) State Waterbody lists prior to this assessment. Appendix B of the Assessment Report summarizes the data collected during the period of July 1999 to September 2000.

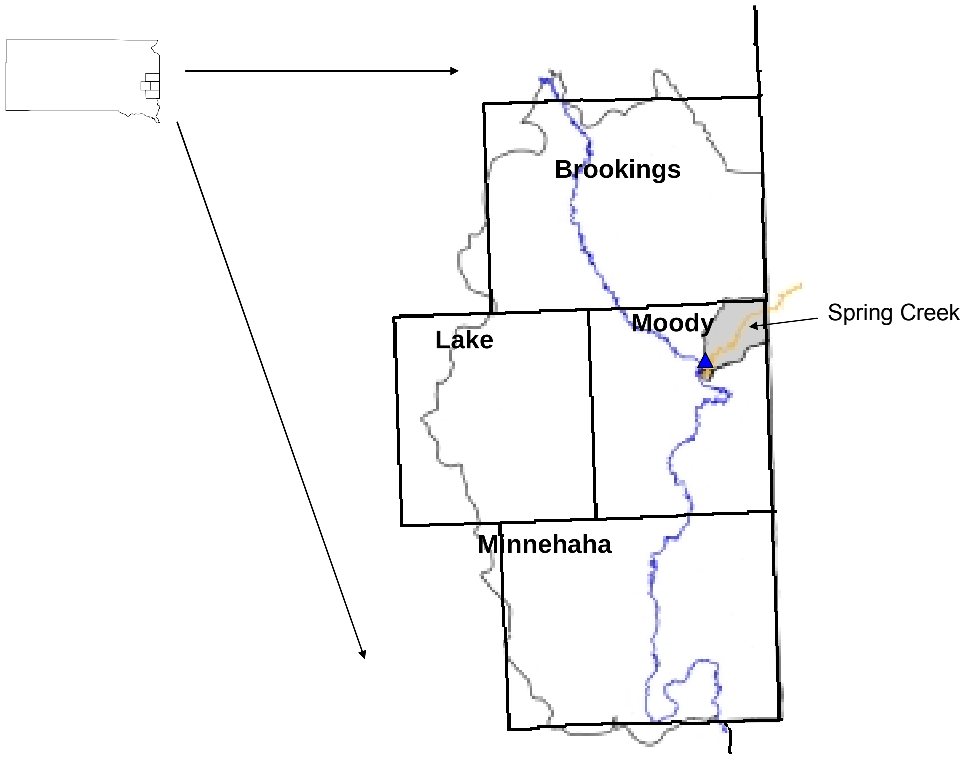


Figure 1. Location of the Spring Creek Watershed in South Dakota

Problem Identification

Although Spring Creek begins in Minnesota, the Central Big Sioux River Watershed Assessment evaluated only the portion within South Dakota. This portion begins in south-eastern Brookings County and eventually joins the Big Sioux River about three miles north of the City of Flandreau. The watershed area shown in Figure 2 drains approximately 98 percent grass/grazing land and cropland acres. The City of Elkton is the only municipality located within the study area.

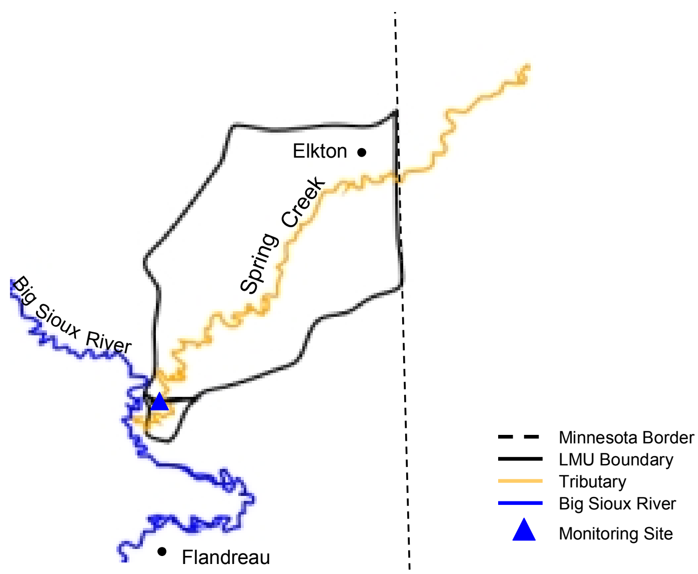


Figure 2. Spring Creek Watershed

Spring Creek (T11) was found to carry fecal coliform bacteria which degrades water quality. This tributary is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters for fecal coliform bacteria. Table 1 displays the fecal coliform data collected from July 1999 to September 1999 and from May 2000 to September 2000.

Table 1. Summary of Fecal Coliform Data for Spring Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	11	45.5	270	9,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Spring Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream segment. These criteria must be maintained for the tributary to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involves monitoring the levels of fecal coliform from May 1 though September 30. Spring Creek is identified as not supporting its limited contact recreation beneficial use. This stream segment experiences fecal coliform loading due to absent or poor riparian areas, manure runoff, concentrated feedlots, and NPDES systems.

To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

Spring Creek currently has a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this tributary. This methodology, developed by Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). However, due to the low number of samples per zone, all zones were combined to assess the overall fecal coliform bacteria problem. The methodology of flow duration intervals is explained further in the Methods Section of the Assessment Report.

One monitoring location, T11, was setup on Spring Creek. Of the 11 water samples that were collected, five (or 45.5 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, Spring Creek does not currently support its limited contact recreation beneficial use (Appendix FF, Appendix Report). A majority of the problems were documented during high flows and moist conditions. It should be noted that Spring Creek joins the Big Sioux River just north of the City of Flandreau. At this point, the Big Sioux River is also assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria and is currently fully supporting its beneficial use of limited contact recreation (Figure 3).

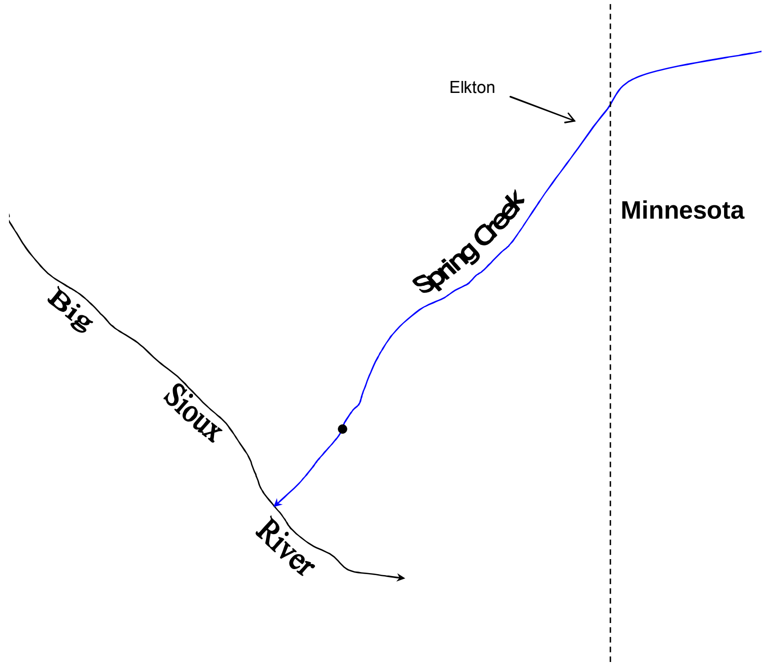


Figure 3. Water Flow in the Spring Creek Watershed

Pollutant Assessment

Point Sources

The City of Elkton was the only identified NPDES facility in the watershed (Table 3). Total contribution from this facility during the study period was insignificant at 0.00016 percent. Calculations used total colonies from the facility divided by the total colonies at Site T11. The potential load from the facilities is shown in Table 3.

Table 3. NPDES Facilities.

Facility Name	Permit Number	# colonies/day
Elkton	SD0020788	8.10E+10

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. The livestock data collected during the AGNPS Feedlot modeling is listed in Table 4.

Table 4. Livestock Distribution for the Spring Creek Watershed

Livestock Distribution	Spring Creek
Beef Cattle/Calves	3490
Hogs/Pigs	370
Dairy Cattle	40

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 5 shows that 98 percent of the area is grass or cropland. Urban areas would fall into the artificial category, which makes up approximately one percent of the watershed.

Table 5. Landuse in the Spring Creek Watershed

LandUse	Percent	Acres
Water	0%	10
Trees	1%	225
Artificial	1%	384
Barren	0%	6
Grass	34%	10,758
LEP Cropland	62%	19,808
MEP Cropland	1%	359
HEP Cropland	1%	193

LEP = Low Erosion Potential
MEP = Medium Erosion Potential
HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at one monitoring site (T11) on Spring Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for Spring Creek, the range of flows from the monitoring location were divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-range (40-60), Dry (60-90), and Low (90-100). Excessive fecal coliform loadings are occurring mainly during the moist to high flow conditions. Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 4, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (See Attachment 1 for details). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

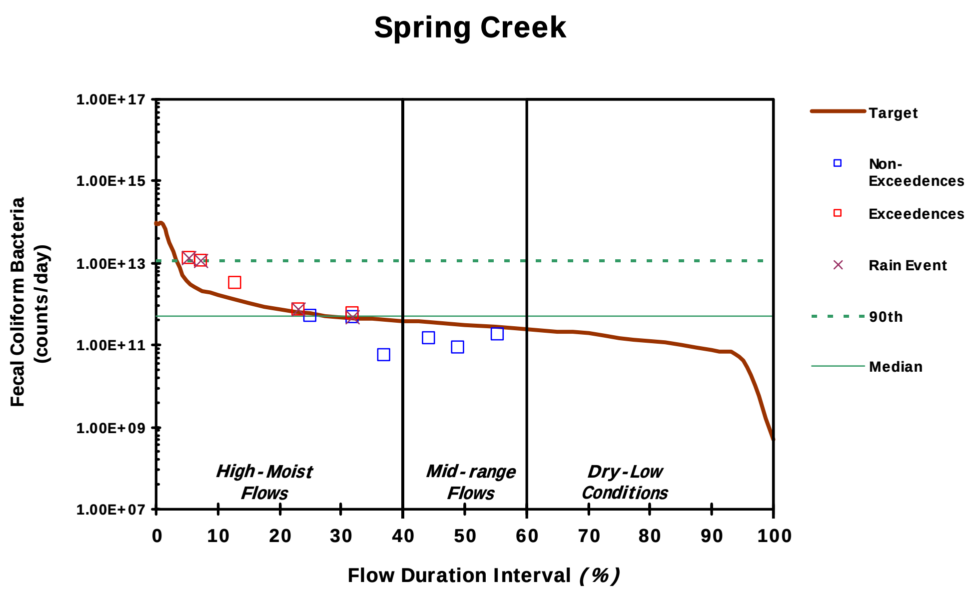


Figure 4. Flow Duration Interval for the Spring Creek Watershed

Table 6. Fecal Coliform Target Loads for Flow

		Allowable Loads 2000 cfu/100mL	
Flow Rank (percent)	**cfs**	**Fecal Coliform (counts/day)**	**Flow Conditions**
0.019	2028.40	9.93E+13	Peak
0.100	1885.00	9.23E+13	
0.274	1861.00	9.11E+13	
1	1850.00	9.05E+13	
5	79.00	3.87E+12	
10	35.00	1.71E+12	
15	22.00	1.08E+12	
20	15.46	7.57E+11	
25	12.21	5.97E+11	
30	10.00	4.89E+11	
35	9.00	4.40E+11	
40	7.90	3.87E+11	
45	7.02	3.43E+11	
50	6.17	3.02E+11	
55	5.70	2.79E+11	
60	5.10	2.50E+11	
65	4.50	2.20E+11	
70	4.00	1.96E+11	
75	3.10	1.52E+11	
80	2.60	1.27E+11	
85	2.10	1.03E+11	
90	1.60	7.83E+10	
95	0.85	4.16E+10	
100	0.01	4.89E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze current feedlots and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agriculture related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 7 lists the feedlots for each LMU within this watershed that rated 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying the region of concern is shown in Figure 5. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 7. Feedlot Ratings ≥ 50 for Spring Creek Watershed

LMU	Feedlot Rating
11	53
11	53
11	54
11	65
11	69
11	70
11	78
11	83
R	59

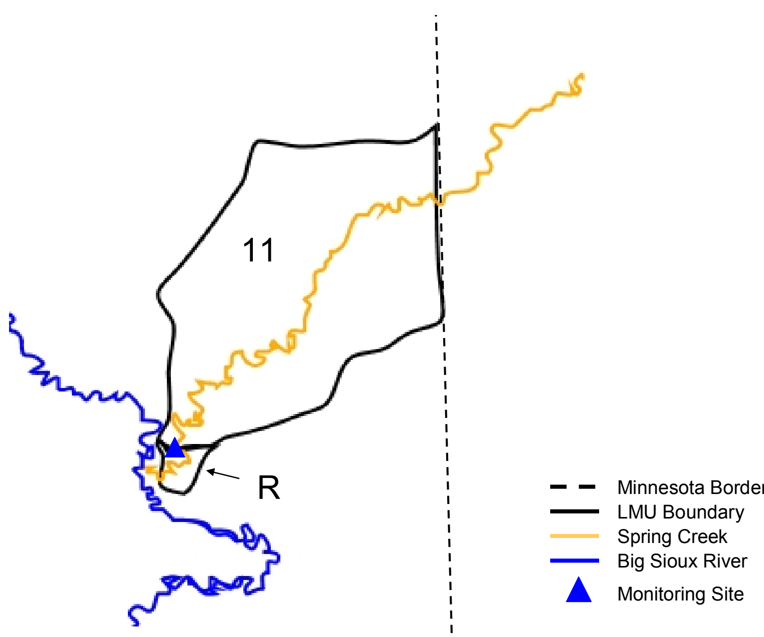


Figure 5. LMUs of the Spring Creek Watershed

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)
			Overall Conditions
SD-BS-R-SPRING_01		TMDL	3.02E+11
		10% MOS	3.02E+10
		Total Allocations	2.72E+11
		LA	1.91E+11
	Elkton (WWTF)	WLA	8.10E+10
		Background	3.82E+09
		Other NPS	1.87E+11

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the particular stream. The worst case scenario of all point source waste loads within this segment would be approximately 8.10×10^{10} fecal counts if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Of the five samples collected at T11 that were exceeding the ≤ 2,000 cfu/100mL standard, three (or 60 percent) occurred during a rain event.

Margin of Safety
The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions
The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring
Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation
Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Spring Creek TMDL.

Implementation Plan
The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from the overall flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 45 percent for under all flow conditions (Table 8). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Using the individual flowzones results in two flowzones with no samples and no reductions. A more conservative approach using the overall conditions was taken to aid implementation efforts after the entire landuse data and size of the watershed was considered. The following table shows the reductions if three flowzones were used compared to one overall zone.

Table 8. Flowzone Reduction Comparison

	Median	Overall (0-100)	High/Moist (0-40)	Mid-Range (40-60)	Dry/Low (60-100)
	Median Concentration (counts/day)	8.15E+10	4.33E+10	2.45E+10	0.00E+00
X	Flow Median (cfs)	6.17	15.46	6.17	2.60
=	Existing	5.03E+11	6.69E+11	1.51E+11	0.00E+00
	Target Load (at 2,000 cfu/100mL)	3.02E+11	7.57E+11	3.02E+11	1.27E+11
	% Reduction w/MOS	45	-2.79	-81.87	0.00
Note: units are counts/day					
	Median Flow Percentilie	50	20	50	80
	Number of Samples per Zone	11	8	3	0

Fecal Exceedences for Spring Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T11	05/31/00	1345	53.09	0.0717	7.17	9000.0	1.17E+13
T11	05/19/00	1045	71.09	0.0544	5.44	7600.0	1.32E+13
T11	07/12/00	1230	25.22	0.1285	12.85	5300.0	3.27E+12
T11	06/14/00	945	10.00	0.3186	31.86	2400.0	5.87E+11
T11	05/16/00	1435	13.95	0.2318	23.18	2200.0	7.51E+11

Appendix YY.
TMDL – Flandreau Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Flandreau Creek
(within South Dakota)

(HUC 10170203)

Moody County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Flandreau Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-FLANDREAU_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation, Recreation and Stock Watering Irrigation
Length of Stream:	9.78 miles (within South Dakota)
Size of Watershed:	13,166 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of Limited Contact Recreation Beneficial Use from durng the months of May through September
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective
The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction
Flandreau Creek is a 9.78 mile segment (within South Dakota) with a watershed of approximately 13,166 acres, which includes LMUs 12 and T. Flandreau Creek is a tributary to the Big Sioux River in eastern Moody County, South Dakota. The South Dakota portion of the watershed lies within Moody County, shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1. Flandreau Creek was not on the 2006 303(d) Waterbody list.

The Central Big Sioux River Watershed Assessment Project has identified Flandreau Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Flandreau Creek was not on any 303(d) State Waterbody lists prior to this assessment. Appendix B of the Assessment Report summarizes the data collected during the period of July 1999 to September 2000.

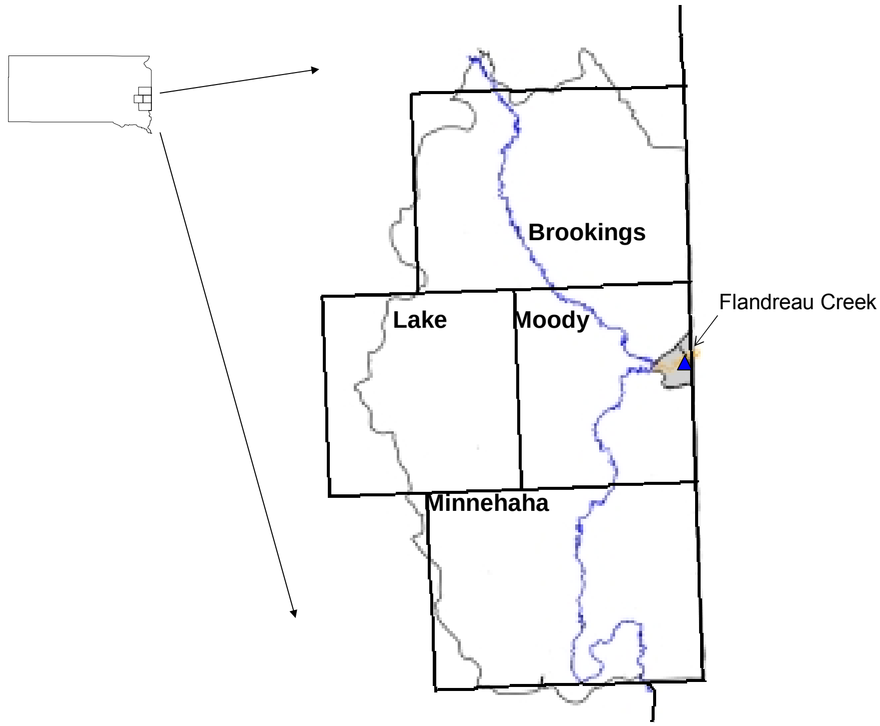


Figure 1. Location of the Flandreau Creek Watershed in South Dakota

Problem Identification

The Central Big Sioux River Watershed Assessment Project evaluated the portion of the Flandreau Creek watershed within South Dakota, which begins in eastern Moody County and then joins the Big Sioux River above the City of Flandreau. However, 90 percent of the Flandreau Creek watershed is located within Minnesota. The watershed portion in South Dakota (Figure 2) drains approximately 98 percent grass/grazing land and cropland acres. One municipality (Town of Lake Benton) is located in the Minnesota portion of the watershed.

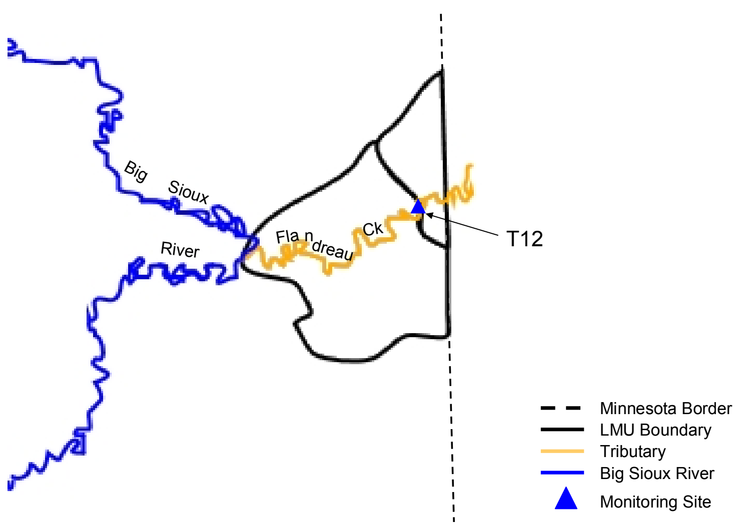


Figure 2. Flandreau Creek Watershed

Flandreau Creek (T12) was found to carry fecal coliform bacteria which degrades water quality. This tributary is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters for fecal coliform bacteria during the season of May 1 to September 30. Table 1 displays the fecal coliform data collected from July 1999 to September 1999 and from May 2000 to September 2000.

Table 1. Summary of Fecal Coliform Data for Flandreau Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	11	36.4	270	10,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Flandreau Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). In conjunction with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involves monitoring the levels of fecal coliform from May 1 though September 30. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Flandreau Creek is identified as not supporting its limited contact recreation beneficial use. This segment experiences fecal coliform loading due to poor riparian areas, in-stream livestock, feedlots/manure runoff, stormwater runoff, and NPDES systems.

Willow Creek, a sub-tributary, joins Flandreau Creek within Minnesota, and may be another source of fecal coliform bacteria pollution. Although 90% of this watershed resides in Minnesota, no water quality information from either the portion of Flandreau Creek in Minnesota or Willow Creek has been used to establish this TMDL. Data collected from this study indicates that the fecal coliform problem is likely stemming from the Minnesota portion of the watershed.

Flandreau Creek currently has a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this tributary. This methodology, developed by Dr. Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Dr. Cleland's approach, the following four hydrologic conditions were utilized: High Flows/Moist Conditions (0-40 percent), Mid-Range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows

(90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

One monitoring location, T12, was setup on Flandreau Creek, which is located 1 mile west of the border of Minnesota and South Dakota. Of the 11 water samples that were collected, four (or 36.4 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this creek is currently not supporting its assigned beneficial uses (Appendix FF, Assessment Report). It should be noted that Flandreau Creek joins the Big Sioux River just north of the City of Flandreau. At this point, the Big Sioux River is also assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria and is currently fully supporting its beneficial use of limited contact recreation. It is unknown what the condition of Flandreau Creek is between Site T12 and the Big Sioux River.

Pollutant Assessment

Point Sources

There are no identified NPDES facilities within the South Dakota portion of the watershed.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES facilities, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 2.

Table 2. Livestock Distribution for the Flandreau Creek Watershed

Livestock Distribution	Flandreau Creek
Beef Cattle/Calves	500
Hogs/Pigs	0
Dairy Cattle	0

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. Fecal coliform from failing septic systems may be absorbed in the soil and vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Land Use

Landuse in the South Dakota portion of the watershed was derived from the Sediment Delivery Model. Table 3 shows that 98 percent of the area is grass or cropland.

Table 3. Landuse in the Flandreau Creek Watershed

Landuse	Percent	Acres
Water	0%	11
Trees	2%	216
Artificial	1%	119
Barren	0%	22
Grass	36%	4,780
LEP Cropland	56%	7,305
MEP Cropland	4%	483
HEP Cropland	2%	231

LEP = Low Erosion Potential
MEP = Medium Erosion Potential
HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at one monitoring site (T12) on Flandreau Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were sent to the Water Resource Institute, at South Dakota State University in Brookings, for analysis. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for Flandreau Creek, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. For this tributary, the ranges or flow zones are High/Moist (0-40), Mid-range (40-60), Dry (60-90), and Low (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (See Attachment 1 for details). Table 4 depicts the allowable coliform bacteria load for peak flow, low flow, and 5^{th} percentile increments in flow.

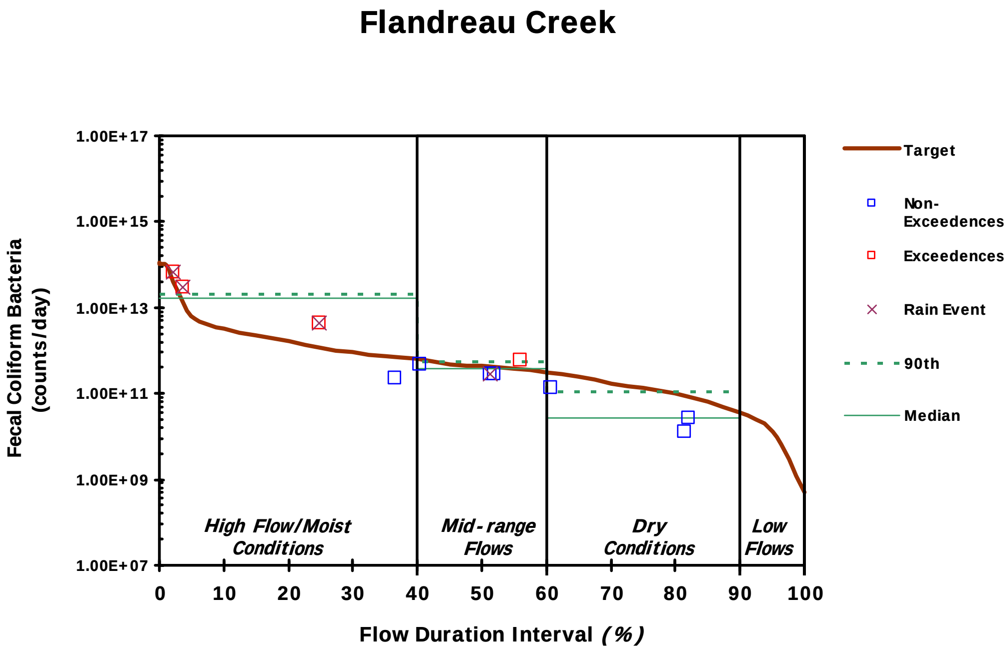


Figure 3. Flow Duration Interval for the Flandreau Creek Watershed

Table 4. Fecal Coliform Target Loads for Flow

		Allowable Loads 2000 cfu/100mL	
Flow Rank (percent)	cfs	Fecal Coliform (counts/day)	Flow Conditions
0.019	2338.00	1.14E+14	Peak
0.100	2117.00	1.04E+14	
0.274	2072.00	1.01E+14	
1	2050.00	1.00E+14	
5	129.50	6.34E+12	
10	67.00	3.28E+12	
15	47.00	2.30E+12	
20	33.00	1.62E+12	
25	24.00	1.17E+12	
30	19.00	9.30E+11	
35	15.00	7.34E+11	
40	13.00	6.36E+11	
45	10.00	4.89E+11	
50	9.00	4.40E+11	
55	8.00	3.92E+11	
60	6.34	3.10E+11	
65	5.00	2.45E+11	
70	3.50	1.71E+11	
75	2.70	1.32E+11	
80	2.00	9.79E+10	
85	1.30	6.36E+10	
90	0.75	3.67E+10	
95	0.27	1.32E+10	
100	0.01	4.89E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze current feedlots and their pollution potential. The feedlot assessment was performed in the South Dakota portion of the watershed. It was assumed the probable sources of fecal coliform bacteria loadings were agriculture related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. All 12 feedlots identified were located in LMU T (Figure 4). Only one of these feedlots rated ≥ 50. The rating for this particular feedlot was 64. A higher rating suggests that this feedlot has a greater potential to pollute nearby surface waters. Since none of the feedlots were located upstream from this monitoring site (located one mile from the Minnesota border), the excess fecal coliform bacteria loading at this monitoring site is directly related to operations in Minnesota. The Minnesota Pollution Control Agency is willing to work with the State of South Dakota in implementing this TMDL. A complete methodology report can be found in Appendix CC of the Assessment Report.

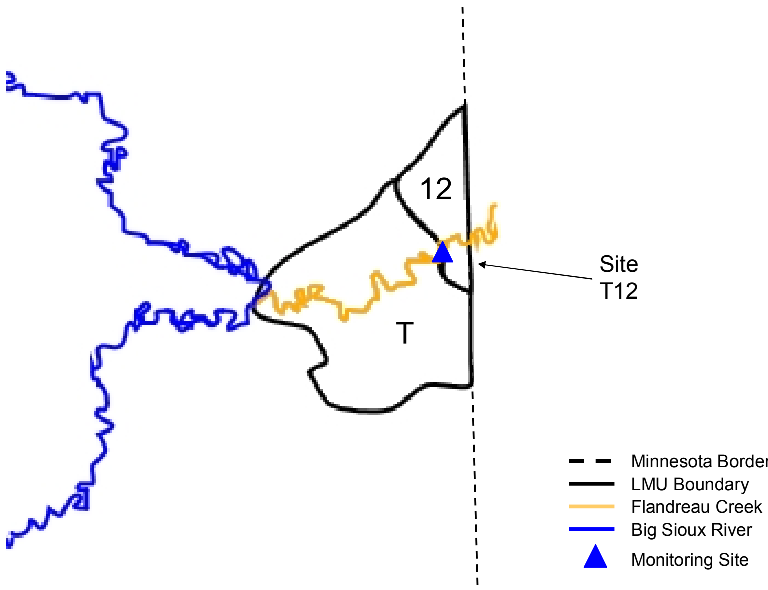


Figure 4. LMUs of the Flandreau Creek Watershed in South Dakota

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)		
			High/Moist	**Mid-Range**	**Dry**
SD-BS-R-FLANDREAU_01		TMDL	1.62E+12	4.40E+11	1.32E+11
		10% MOS	1.62E+11	4.40E+10	1.32E+10
		Total Allocations	1.46E+12	3.96E+11	1.19E+11
		LA	1.46E+12	3.96E+11	1.19E+11
		WLA	0	0	0
		Background	2.92E+10	7.92E+09	2.38E+09
		Other NPS	1.43E+12	3.88E+11	1.17E+11

Wasteload Allocations (WLAs)
There are no identified point sources in this watershed. Therefore, the "wasteload allocation" component of this TMDL will be zero.

Load Allocations (LAs)
Load allocations account for the portion of the TMDL assigned to non-point sources and is based on the flow duration interval approach. Since there are no WLAs within this watershed, load allocations from non-point sources account for the total target load. Non-point sources of pollution include cropland, pastureland, and residential areas. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background (See TMDL table above).

Seasonal Variation
Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Monitoring Site T12 is not meeting the water quality criteria for fecal coliform bacteria. Of the four samples collected at T12 that were exceeding the standard, 75 percent occurred during a rain event.

Margin of Safety
The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions
The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring
Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria.

Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation
Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Flandreau Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this tributary. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. Cooperation with the State of Minnesota will also be needed in order to meet this TMDL.

In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 91 percent during high to moist flow conditions (Table 5). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 5. Flandreau Creek Fecal Coliform Bacteria Reductions

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (counts/day)	5.06E+11	4.22E+10	1.00E+10	------
X	Flow Median (cfs)	33	9	2.7	------
=	Existing Load	1.67E+13	3.80E+11	2.70E+10	------
	Target Load (at 2,000 cfu/100mL)	1.62E+12	4.40E+11	1.32E+11	1.32E+10
	% Reduction w/MOS	91	0	0	------

Note: units are counts/day

Fecal Exceedences for Flandreau Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T12	05/31/00	1400	274.15	0.0208	2.08	10000	6.71E+13
T12	05/16/00	1510	24.66	0.2480	24.80	7500	4.53E+12
T12	05/19/00	1120	171.26	0.0370	3.70	6900	2.89E+13
T12	07/12/00	1315	7.65	0.5607	56.07	3100	5.80E+11

Appendix ZZ.
TMDL – Jack Moore Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Jack Moore Creek

(HUC 10170203)

Moody County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Jack Moore Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-JACK_MOORE_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Stream:	18.6 miles
Size of Watershed:	37,415 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective
The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction
Jack Moore Creek is an 18.6 mile stream with a watershed of approximately 37,415 acres (includes LMUs 13 and U) and is a tributary to the Big Sioux River in central Moody County, South Dakota. The watershed of this stream segment lies within west-central Moody County as shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

The Central Big Sioux River Watershed Assessment Project identified Jack Moore Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Jack Moore Creek was not on any 303(d) State Waterbody lists prior to this assessment. Appendix B of the Assessment Report summarizes the data collected during the Central Big Sioux River Watershed Assessment Project from July 1999 to September 2000. Jack Moore Creek was not listed on the 2006 303(d) Waterbody list.

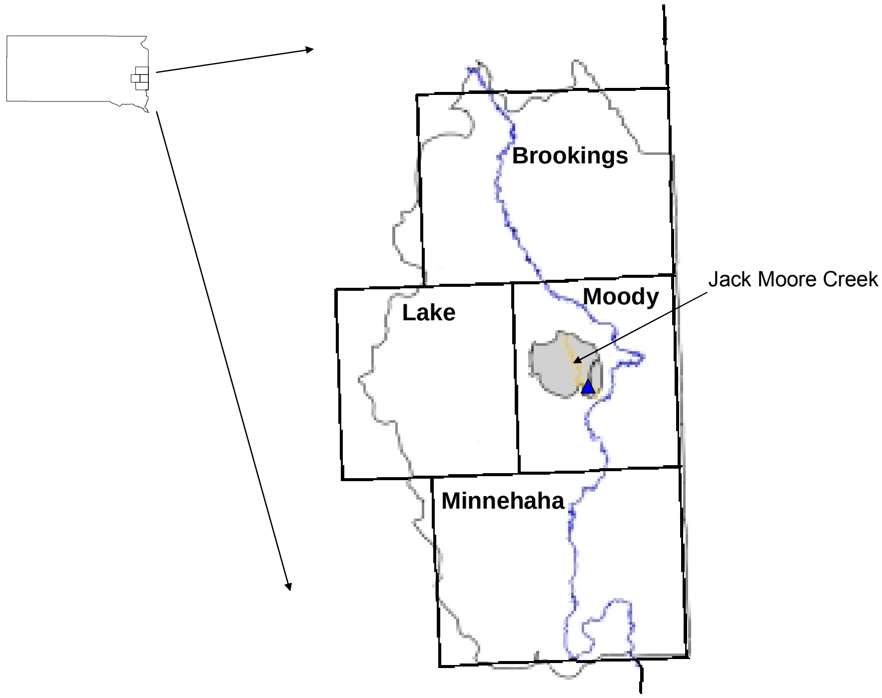


Figure 1. Location of the Jack Moore Creek Watershed in South Dakota

Problem Identification

Jack Moore Creek begins in central Moody County, and then joins the Big Sioux River below the City of Egan (Figure 2). The watershed area shown in Figure 2 drains approximately 96 percent grass/grazing land and cropland acres. There are no municipalities located in this area.

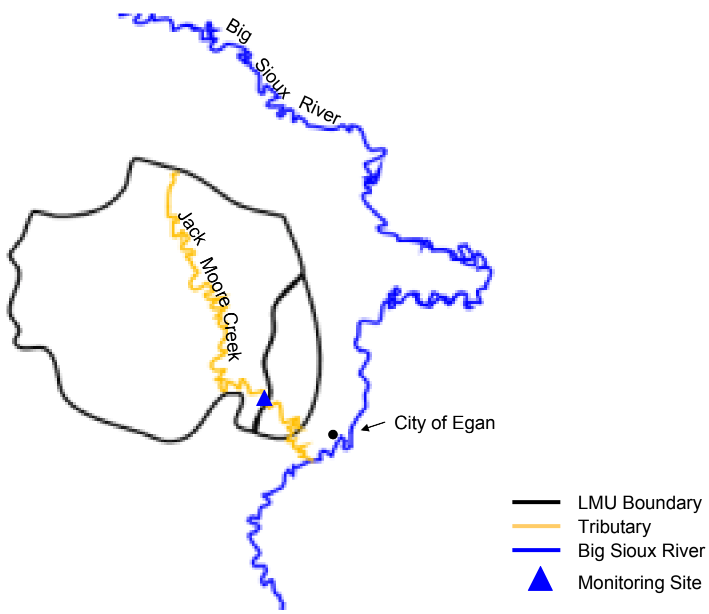


Figure 2. Jack Moore Creek Watershed

Jack Moore Creek (T13) was found to carry fecal coliform bacteria which degrades water quality. This tributary is considered impaired because more than 25 percent of the values (of less than 20 samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters of fecal coliform bacteria. Table 1 displays the fecal coliform data collected from July 1999 to September 1999 and from May 2000 to September 2000.

Table 1. Summary of Fecal Coliform Data for Jack Moore Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	9	55.6	700	19,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Jack Moore Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involves monitoring the levels of fecal coliform from May 1 though September 30. This segment experiences fecal coliform loading due to absent or poor riparian areas, pastured livestock, and manure/feedlot runoff.

To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Jack Moore Creek currently has a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach the following three hydrologic conditions were utilized: High/Moist Conditions (0-40 percent), Mid-Range (40-60 percent), and Dry/Low Flow Conditions (60-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

One monitoring location, T13, was setup on Jack Moore Creek. Of the nine water samples that were collected, five (or 55.6 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this segment is currently not supporting its limited contact recreation beneficial use (Appendix FF, Assessment Report). It should be noted that Jack Moore Creek joins the Big Sioux River just south of the City of Egan. At this point, the

Big Sioux River is also assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria and is currently fully supporting its beneficial use of limited contact recreation. The condition of Jack Moore Creek between Site T13 and the Big Sioux River is unknown.

Pollutant Assessment

Point Sources

There are no identified NPDES facilities within this watershed.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 2.

Table 2. Livestock Distribution for the Jack Moore Creek Watershed

Livestock Distribution	Jack Moore Creek
Beef Cattle/Calves	3336
Horses	5
Dairy Cattle	235
Sheep	220

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. Fecal coliform from failing septic systems may be absorbed in the soil and vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 3 shows that 96 percent of the area is grass or cropland.

Table 3. Landuse in the Jack Moore Creek Watershed

Landuse	Percent	Acres
Water	1%	374
Trees	1%	486
Artificial	1%	449
Barren	0%	37
Grass	29%	10,850
LEP Cropland	66%	34,844
MEP Cropland	1%	299
HEP Cropland	0%	75

LEP = Low Erosion Potential
MEP = Medium Erosion Potential
HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at one monitoring site (T13) on Jack Moore Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria in Jack Moore Creek, the flow duration interval curve was divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. For this segment, the ranges or flow zones are High/Moist Conditions (0-40), Mid-Range (40-60), and Dry/Low Flows (60-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (See Attachment 1 for details). Table 4 depicts the allowable coliform bacteria load for peak flow, low flow, and 5th percentile increments in flow.

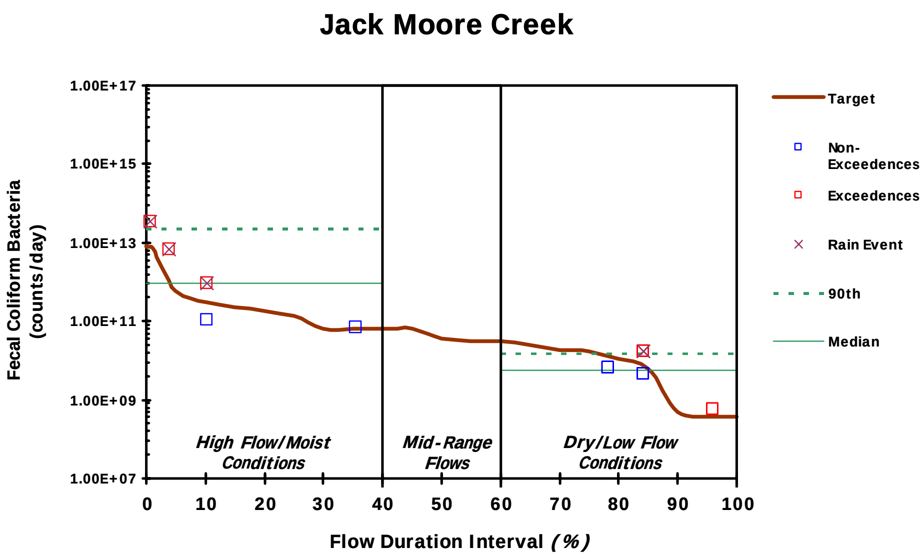


Figure 3. Flow Duration Interval for Jack Moore Creek

Table 4. Fecal Coliform Target Loads for Flow

		Allowable Loads 400 cfu/100mL	
Flow Rank (percent)	**cfs**	**Fecal Coliform (counts/day)**	**Flow Conditions**
0.019	175.52	8.59E+12	Peak
0.100	162.01	7.93E+12	
0.274	158.06	7.74E+12	
1	155.59	7.61E+12	
5	12.06	5.90E+11	
10	6.41	3.14E+11	
15	4.85	2.37E+11	
20	3.61	1.77E+11	
25	2.78	1.36E+11	
30	2.01	6.65E+10	
35	1.62	6.31E+10	
40	1.36	6.65E+10	
45	1.29	6.31E+10	
50	0.75	3.68E+10	
55	0.62	3.04E+10	
60	0.62	3.04E+10	
65	0.49	2.42E+10	
70	0.37	1.81E+10	
75	0.35	1.70E+10	
80	0.22	1.09E+10	
85	0.13	6.18E+09	
90	0.01	4.89E+08	
95	0.01	3.75E+08	
100	0.01	3.75E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze current feedlots and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agriculture related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 5 lists the 12 feedlots that rated 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying the region of concern in shown in Figure 4. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 5. Feedlot Ratings ≥ 50 for Jack Moore Creek Watershed

LMU	Feedlot Rating
13	51
13	54
13	54
13	57
13	59
13	60
13	68
13	69
13	73
U	54
U	57
U	60

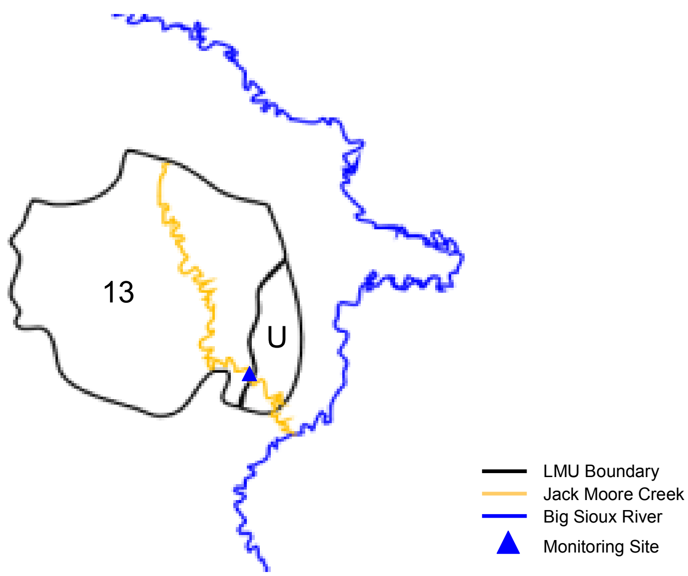


Figure 4. LMUs of the Jack Moore Creek Watershed

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)		
			High/Moist	Mid-Range	Dry
SD-BS-R-JACK_MOORE_01		TMDL	1.77E+11	3.68E+10	1.09E+10
		10% MOS	1.77E+10	3.68E+09	1.09E+09
		Total Allocations	1.59E+11	3.31E+10	9.81E+09
		LA	1.59E+11	3.31E+10	9.81E+09
		WLA	0	0	0
		Background	3.18E+09	6.62E+08	1.96E+08
		Other NPS	1.56E+11	3.24E+10	9.61E+09

Wasteload Allocations (WLAs)

There are no identified point sources in this watershed. Therefore, the "wasteload allocation" component of this TMDL will be zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Since there are no WLAs within this watershed, load allocations from non-point sources account for the total target load. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Monitoring site T13 is not meeting the water quality criteria for fecal coliform bacteria. Of the five samples taken at T13 that were exceeding the ≤ 2,000 cfu/100mL standard, three (or 60 percent) occurred during a rain event.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Jack Moore Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this tributary. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 82 percent during high to moist flow conditions (Table 6). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 6. Jack Moore Creek Fecal Coliform Bacteria Reductions

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry/Low (60-100)
	Median Concentration (counts/day)	2.52E+11	-----	2.52E+10
X	Flow Median (cfs)	3.61	0.75	0.22
=	Existing	9.10E+11	-----	5.55E+09
	Target Load (at 2,000 cfu/100mL)	1.77E+11	36800000000	1.09E+10
	% Reduction w/MOS	82	-----	0

Note: units are counts/day

Fecal Exceedences for Jack Moore Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T13	05/31/00	1445	14.54	0.0382	3.82	19000	6.76E+12
T13	05/19/00	1230	102.56	0.0055	0.55	13500	3.39E+13
T13	05/08/00	1445	6.41	0.1035	10.35	5800	9.10E+11
T13	07/12/00	1400	0.13	0.8427	84.27	5800	1.79E+10
T13	08/10/99	1330	0.01	0.9597	95.97	3200	5.99E+08

Appendix AAA.
TMDL – Split Rock Creek (TSS)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Total Suspended Solids)

for

Split Rock Creek
(within South Dakota)

(HUC 10170203)

Minnehaha County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Split Rock Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-SPLIT_ROCK_01_USGS
303(d) Listing Parameter:	Suspended Solids
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Immersion Recreation Limited Contact Recreation Fish and Wildlife Propagation, Recreation, and Stock Watering Irrigation
Length of Stream:	28.0 miles (within South Dakota)
Size of Watershed:	168,525 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models including Flow Duration Interval Zones and the Sediment Delivery Model (SDM)
Location:	HUC Code: 10170203
Goal:	Full Support of the Warmwater Semi-permanent Fish Life Propagation Beneficial Use
Target:	≤ 158 mg/L of total suspended solids (any one sample)

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Split Rock Creek is a 28.0 mile segment (within South Dakota) with a watershed of approximately 168,525 acres, which includes LMUs 26, 27, 28, 29, 30, 31, 33, Z, DD, and GG. Split Rock Creek is a tributary to the Big Sioux River (HUC 10170203) in southeastern Minnehaha County, South Dakota. The watershed of this segment lies within Moody and Minnehaha Counties as shown by the shaded region in Figure 1. This tributary is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1. Split Rock Creek is listed in the 2006 Integrated Report as unknown for its support of warmwater semipermanent fish life propagation, immersion recreation, and limit contact recreation uses.

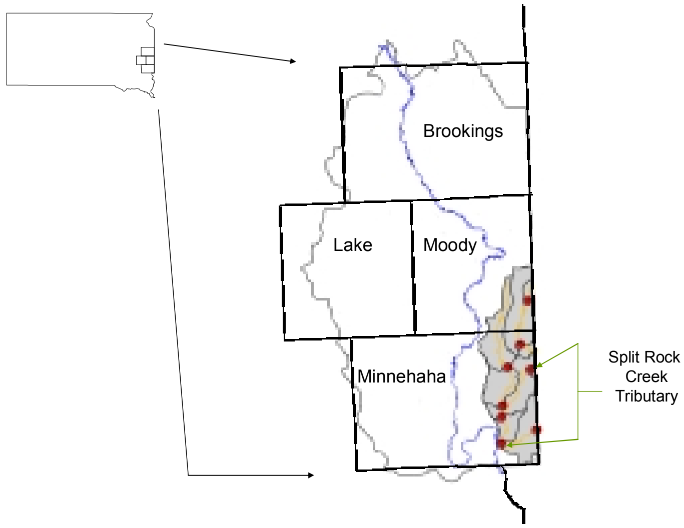


Figure 1. Location of the Split Rock Creek Watershed in South Dakota

Split Rock Creek is influenced by the tributaries of West Pipestone Creek, Pipestone Creek, and Beaver Creek. The Central Big Sioux River Watershed Assessment Project has identified Split Rock Creek for TMDL development due to not meeting the water quality criteria for suspended solids. Information supporting this listing was derived from monitoring data collected by the East Dakota Water Development District. Appendix B of the Assessment Report summarizes the data collected during the period of June 2000 to October 2001.

Problem Identification

Although Split Rock Creek begins near Pipestone, Minnesota, the Central Big Sioux River Watershed Assessment evaluated only the portion within South Dakota. This portion begins at monitoring site T30, until it joins the Big Sioux River below the City of Brandon. The watershed area shown in Figure 2 drains approximately 99 percent grass/grazing land and cropland acres. This includes the receiving waters of West Pipestone Creek (Sites T26 and T27), Pipestone Creek (Sites T28 and T29), and Beaver Creek (Sites T32 and T33). The municipalities of Brandon, Sherman, Corson, Garretson, and Valley Springs are located in this area.

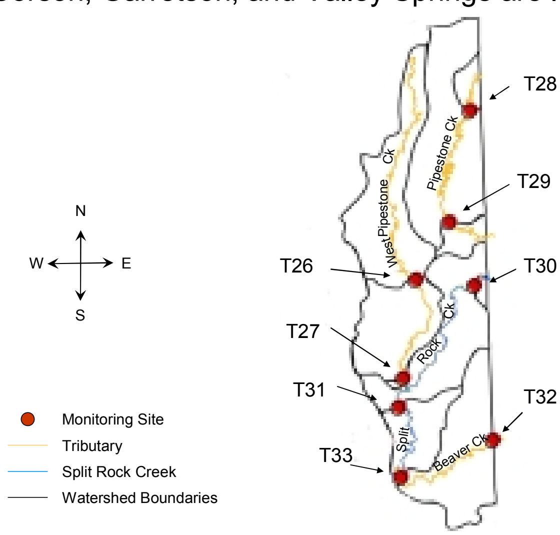


Figure 2. Split Rock Creek Watershed

Split Rock Creek was found to carry excessive sediment which degrades water quality. This tributary is considered impaired because more than 10 percent of the values (of more than 20 samples) exceeded the numeric criteria of ≤ 158 mg/L of total suspended solids per grab sample. A total of 32 water quality samples were taken from two monitoring locations (T30 and T31). Of these 32 samples, 19 percent were violating the water quality standards (Table 1). This 19 percent indicates that this tributary is not meeting the water quality criteria for beneficial use (5) Warmwater Semi-permanent Fish Life Propagation. The excess sediment is believed to be coming from cropland runoff and bed/bank erosion.

Table 1. Summary of Total Suspended Solids Data for Split Rock Creek

Parameter Causing Impairment	Number of Samples	Percent of Samples > 158 mg/L	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
TSS	32	18.8	4	972

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Split Rock Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this tributary. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Warmwater semi-permanent fish propagation
- Immersion recreation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

The tributaries flowing into Split Rock Creek have been assigned a range of beneficial uses as shown by the shaded areas in Table 2.

Table 2. Monitoring Sites and Their Beneficial Use Classification

	Tributaries							
Creek Name	W. Pipestone		Pipestone		Split Rock		Beaver	
Beneficial Uses	T26	T27	T28	T29	T30	T31	T32	T33
Warmwater Semi-permanent Fish Life Propagation								
Warmwater Marginal Fish Life Propagation								
Immersion Recreation								
Limited Contact Recreation								
Fish & Wildlife Propagation, Recreation & Stock Watering								
Irrigation								

Individual parameters determine the support of beneficial uses. This tributary experiences in-stream total suspended solid loading from bed and bank erosion and also external total suspended solid loading from its watershed. Split Rock Creek is identified as not supporting its warmwater semi-permanent fish life propagation beneficial use. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state.

To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Split Rock Creek is currently assigned a numeric standard of ≤ 158 mg/L for TSS. Assessment monitoring indicates that there is a 67 percent exceedence in TSS during high flow conditions. Excessive TSS can decrease water clarity and increase water temperatures. Due to its adsorbing quality, sediment can also carry nutrients, such as phosphorus. This excess in sediment can have adverse affects on fish and other aquatic life. Theoretically, sediment accumulates as it moves downstream. Therefore, the loading at the most downstream monitoring site (T31) was used to determine impairment for this creek.

A flow duration interval with hydrologic zones approach was used to assess this tributary. This methodology, developed by Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

The most downstream monitoring location (T31) was used to assess this stream using the flow duration interval method. Of the 16 water samples collected at this location, four (or 25 percent) violated the water quality standards for total suspended solids. Although this site is fully supporting of its beneficial uses based solely on the grab samples at the downstream site, the flow duration interval indicates this monitoring site has problems with sediment during high flows. Additionally, the combination of grab samples from both monitoring locations on this stream shows a 19 percent violation rate of the water quality standards. Therefore, Split Rock Creek does not currently support its assigned Warmwater Semi-permanent Fish Life Propagation beneficial use. It should be noted that Split Rock Creek joins the Big Sioux River approximately 3 miles south of the City of Brandon. At this point, the Big Sioux River is also assigned a numeric standard of ≤ 158 mg/L for total suspended solids and is currently not supporting its beneficial use of Warmwater Semi-permanent Fish Life Propagation (Figure 3).

Each of the tributaries entering Split Rock Creek was assessed for their level of sediment contribution. Pipestone Creek (Sites T28 and T29) is currently supporting for warmwater semi-permanent fish life propagation at the current numeric standard of ≤ 158 mg/L. It is assumed Pipestone Creek is not having an affect on the excess sediment load of Split Rock Creek.

Beaver Creek (Sites T32 and T33) is not supporting its beneficial uses at the current numeric standard of ≤ 263 mg/L during high flows. Since this tributary directly joins Split Rock Creek, it is assumed this excess sediment is affecting the loading of sediment in Split Rock Creek. A total of 34 water samples were taken from the two monitoring locations on Beaver Creek. Of the 34 samples, 10 (or 29 percent) were violating the water quality standards at ≤ 263 mg/L. In addition, when a more stringent standard of ≤ 158 mg/L is applied, has a significantly higher violation rate during high flows (Attachment 2). A separate TMDL for Beaver Creek has been initiated. It is expected the TMDL for Beaver Creek will satisfy the requirements of this TMDL in regards to the load it is contributing to Split Rock Creek. If this TMDL is insufficient in correcting the sediment loading problem, a more stringent standard may need to be applied to the Beaver Creek tributary in order to meet the downstream goals of Split Rock Creek (See Rule 74:51:01:04 below).
West Pipestone Creek (Sites T26 and T27) does not have an assigned numeric standard for TSS. However, this creek was evaluated at both the ≤ 158 mg/L and the ≤ 263 mg/L numeric

standard. An evaluation of Site T27 at the ≤ 263 mg/L standard indicated reductions in sediment are needed during high flows and moist conditions. Likewise, at the ≤ 158 mg/L standard Site T27 would need higher rates of sediment reductions during high flows and moist conditions (Attachment 3). A total of 31 water quality samples were taken from monitoring sites T26 and T27. Of these 31 samples, eight (or 26 percent) were violating the water quality standards at the ≤ 158 mg/L standard.

According to Rule **74:51:01:04 Application of criterion to contiguous water** states,

> *"If pollutants are discharged into a segment and the criteria for that segments designated beneficial use are not exceeded but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, that pollutants may not cause the more stringent criteria to be exceeded."*

This basically means if one body of water runs into another body of water with a more stringent standard, the more stringent standard would apply to all waters of concern. In this case, Split Rock Creek is assigned a numeric standard of ≤ 158 mg/L for TSS. According to Rule **74:51:01:04**, in order to meet the goals for this tributary, all received waters must also meet the ≤ 158 mg/L numeric criteria for TSS. Therefore, West Pipestone Creek should have a numeric standard of ≤ 158 mg/L assigned and its sediment load reduced. In addition, once the Beaver Creek TMDL is met, it may need to be re-assessed at the ≤ 158 mg/L numeric standard to ensure it is also meeting the goals of Split Rock Creek.

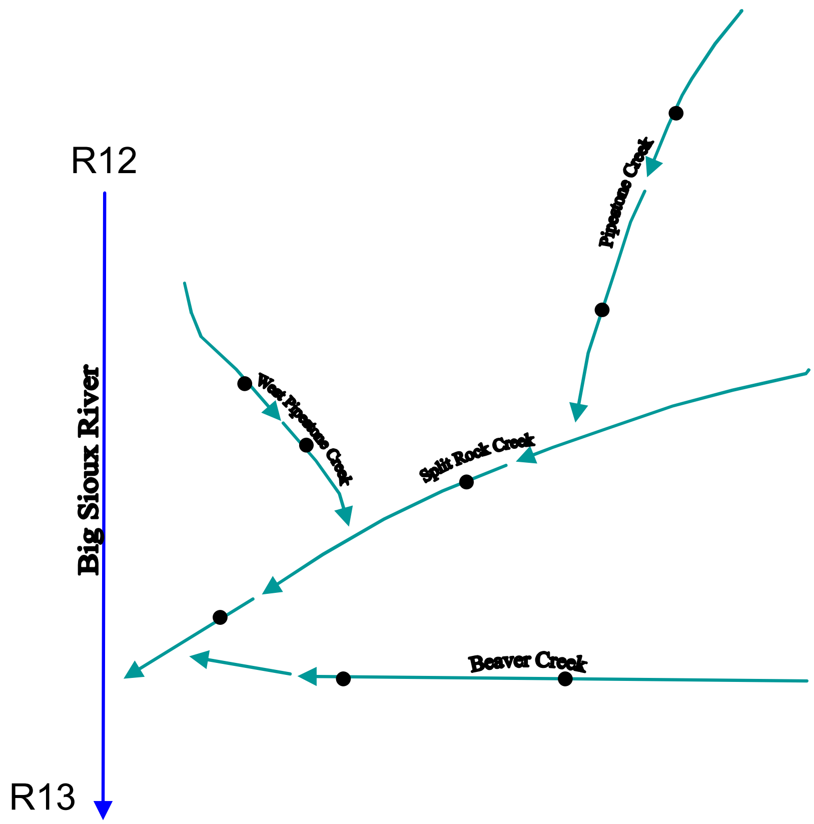


Figure 3. Water Flow for the Tributaries Affecting Split Rock Creek

Best Management Practices (BMPs) targeting high flow conditions will improve sediment levels of Split Rock Creek to an acceptable daily load, with fewer violations of water quality and full support of its beneficial uses. In addition, improvement to Beaver Creek and West Pipestone Creek is necessary to meet the goals of Split Rock Creek.

Pollutant Assessment

Point Sources

The four NPDES facilities taken into consideration within this area are the USGS-EROS Data Center, the City of Garretson, the Corson Village Sanitary District, and the City of Valley Springs (Table 3). Contributions from these facilities during the study period were insignificant, at 0.0005 percent. Calculations used the total kg from Table 30 in the Assessment Report divided by total kg of sediment from monitoring Site T31. The potential load from the facilities is shown in Table 3.

Table 3. NPDES Facilities.

Facility Name	Permit Number	TSS lbs/day
Valley Springs (WWTP)	SD0020923	397.7
Corson (WWTP)	SD0022217	0
EROS (WWTP)	SD0000299	198.3
Garrestson (WWTP)	SD0022560	0

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of total suspended solids include loadings from surface runoff, bed and bank erosion, cropland erosion, construction erosion, and cropland erosion. Figure 4 depicts the flow of water through the watershed. Excessive loading of sediment may indicate problems with cropland erosion and poor riparian areas.

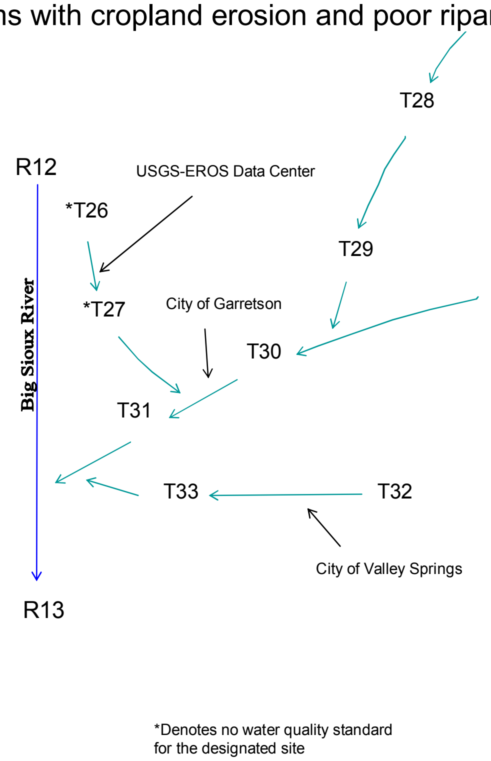


Figure 4. Water Flow in Split Rock Creek Watershed

Linkage Analysis

Water quality data was collected at two monitoring sites on Split Rock Creek and six additional sites from the entering tributaries. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10 percent of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Sediment Delivery Model (SDM) was used to define critical non-point source (NPS) pollution cells within the watershed (those with high sediment) and estimate the effective percent reduction needed in the watershed by adding various Best Management Practices (BMPs). See the Modeling and Results section of the final report for a complete summary of the results. The SDM was used to predict sediment loadings during 2, 5, 10, and 20 year (24 hour) rainfall events (Appendix Y, Assessment Report). Then best management practices, such as stream buffers and tillage practices, were applied to find the achievable percent reductions (Appendix Z, Assessment Report).

The Flow Duration Interval Zone method calculates total suspended solids loading, (concentration) × (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of sediment for Split Rock Creek, the range of flows from the monitoring location were divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-range (40-60), Dry (60-90), and Low (90-100). Excessive sediment loadings are occurring during the high flow conditions. Flow duration intervals were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 4, any samples occurring above this line is an exceedence of the water quality standard and represented by a red box (Attachment 1 contains detailed exceedence information). Table 4 depicts the allowable sediment load during the study for peak flow, low flow, and 5th percentile increments in flow.

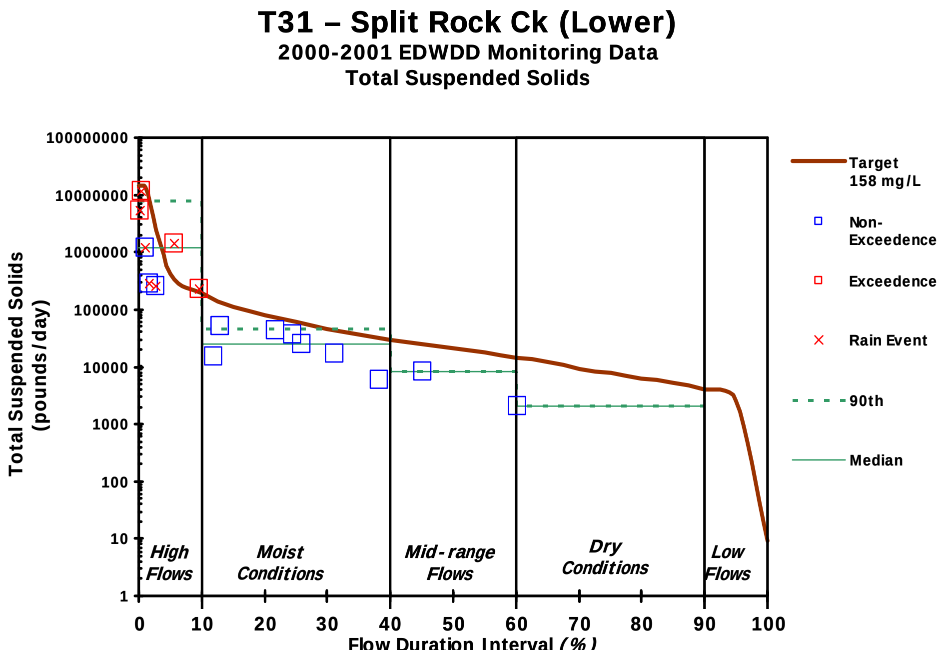


Figure 4. Flow Duration Interval for the Split Rock Creek Watershed

Table 4. Sediment Target Loads for Flow

		Allowable Loads 158 mg/L	
Flow Rank (percent)	cfs	TSS (pounds/day)	Flow Conditions
0.019	17309.72	1.48E+07	Peak
0.100	16623.00	1.42E+07	
0.274	16463.00	1.40E+07	
1	16400.00	1.40E+07	
5	499.10	4.26E+05	
10	223.00	1.90E+05	
15	133.00	1.13E+05	
20	95.00	8.10E+04	
25	70.00	5.97E+04	
30	54.00	4.60E+04	
35	43.00	3.67E+04	
40	34.00	2.90E+04	
45	29.00	2.47E+04	
50	25.00	2.13E+04	
55	21.00	1.79E+04	
60	17.00	1.45E+04	
65	14.00	1.19E+04	
70	11.00	9.38E+03	
75	9.10	7.76E+03	
80	7.50	6.39E+03	
85	6.17	5.26E+03	
90	4.60	3.92E+03	
95	3.00	2.56E+03	
100	0.01	8.53E+00	Low

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as pounds/day)				
			High	Moist	Mid-Range	Dry	Low
SD-BS-R-SPLIT_ROCK_01_USGS		TMDL	4.26E+05	5.97E+04	2.13E+04	7.76E+03	2.56E+03
		10% MOS	4.26E+04	5.97E+03	2.13E+03	7.76E+02	2.56E+02
		Total Allocations	3.83E+05	5.37E+04	1.92E+04	6.98E+03	2.30E+03
		LA	3.82E+05	5.31E+04	1.86E+04	6.39E+03	1.71E+03
	Valley Springs (WWTP)	WLA	3.98E+02	3.98E+02	3.98E+02	3.98E+02	3.98E+02
	Corson (WWTP)	WLA	0	0	0	0	0
	EROS (WWTP)	WLA	1.98E+02	1.98E+02	1.98E+02	1.98E+02	1.98E+02
	Garretson (WWTP)	WLA	0	0	0	0	0
		Background	7.65E+03	1.06E+03	3.72E+02	1.28E+02	3.41E+01
		Other NPS	3.75E+05	5.21E+04	1.82E+04	6.26E+03	1.67E+03

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the suspended solid standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the particular stream. The worst case scenario of all point source waste loads within this segment would be approximately 5.96×10^2 pounds if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet sediment standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the total suspended solids loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute sediment at rates above natural background. This includes cropland, pastureland, bed/bank erosion, and residential areas.

Predictions of sediment reduction were calculated using the SDM. This model shows reductions based on land management units (See Figure 39 in the Assessment Report). Table 5 shows sediment loads during a two year rain event and the achievable reductions using buffers and conservation tillage. Figure 5 shows the locations of the targeted LMUs within the watershed.

Any remaining excess sediment is likely from bed and bank erosion. In which case, stream bank stabilization has shown to improve sediment reduction by 75 to 100 percent.

Table 5. Sediment Loading by LMU for a Two-Year Rain Event and Achievable Reductions

LMU	TSS Yield 2 Year Rain Event (tons)	% Decrease with Stream Buffer	% Decrease With No Tillage	Decrease with Combination Buffer & No Tillage
27	26004	8%	69%	71%
29	22695	13%	72%	75%
DD	130	0%	71%	71%
Z	2514	12%	71%	75%
30	1266	15%	71%	76%
31	28103	11%	72%	74%
26	20087	8%	72%	74%
28	1911	14%	71%	75%
GG	7209	3%	69%	70%
33	24081	8%	70%	72%

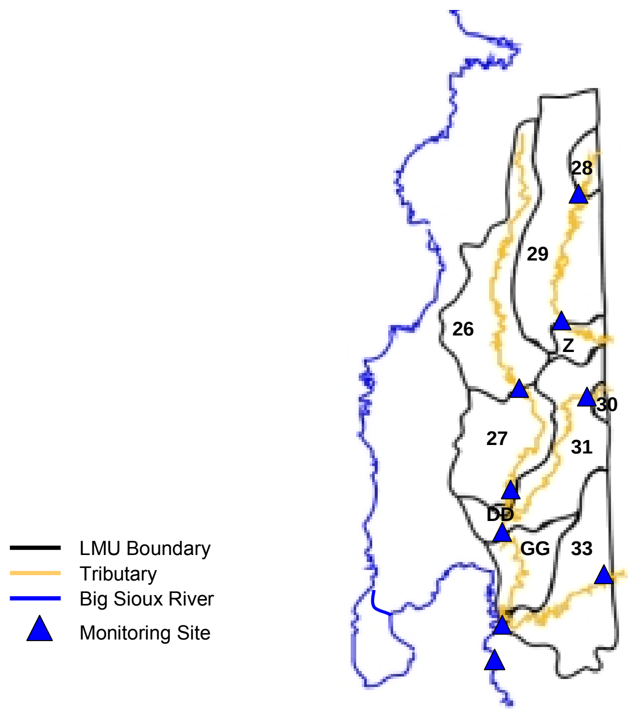


Figure 5. LMUs of the Split Rock Creek Watershed

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. The two Split Rock Creek sites are not meeting the water quality criteria for TSS. Of the samples taken that were exceeding the standard, 100 percent occurred during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10 percent, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions
Violations of the ≤ 158 mg/L standard for TSS occurred during the months of April, June, and July in the Split Rock Creek tributary. This is the result of seasonal precipitation which causes additional particles to be carried into the river.

Follow-Up Monitoring
Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameters of total solids and total suspended solids. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation
Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Split Rock TMDL.

Implementation Plan
The East Dakota Water Development District is working with the City of Sioux Falls and various stakeholders to initiate an implementation project, which is estimated to begin in 2005. It is expected that a local sponsor will request Section 319 funding for project assistance during early 2005.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 158 mg/L) for total suspended solids. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the TSS concentrations by 67 percent under high flow conditions (Table 6). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 6. Estimated Reductions for Split Rock Creek Total Suspended Solids Concentrations.

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	2.36E+03	3.51E+02	3.32E+02	2.32E+02	-----
X	Flow Median (cfs)	499.10	70.00	25.00	9.10	3.00
=	Existing	1.18E+06	2.46E+04	8.29E+03	2.11E+03	-----
	Target Load (at 158 mg/L)	4.26E+05	5.97E+04	2.13E+04	7.76E+03	2.56E+03
	% Reduction w/MOS	67	0	0	0	-----

Note: units are pounds/day

Split Rock Creek Total Suspended Solids Exceedences

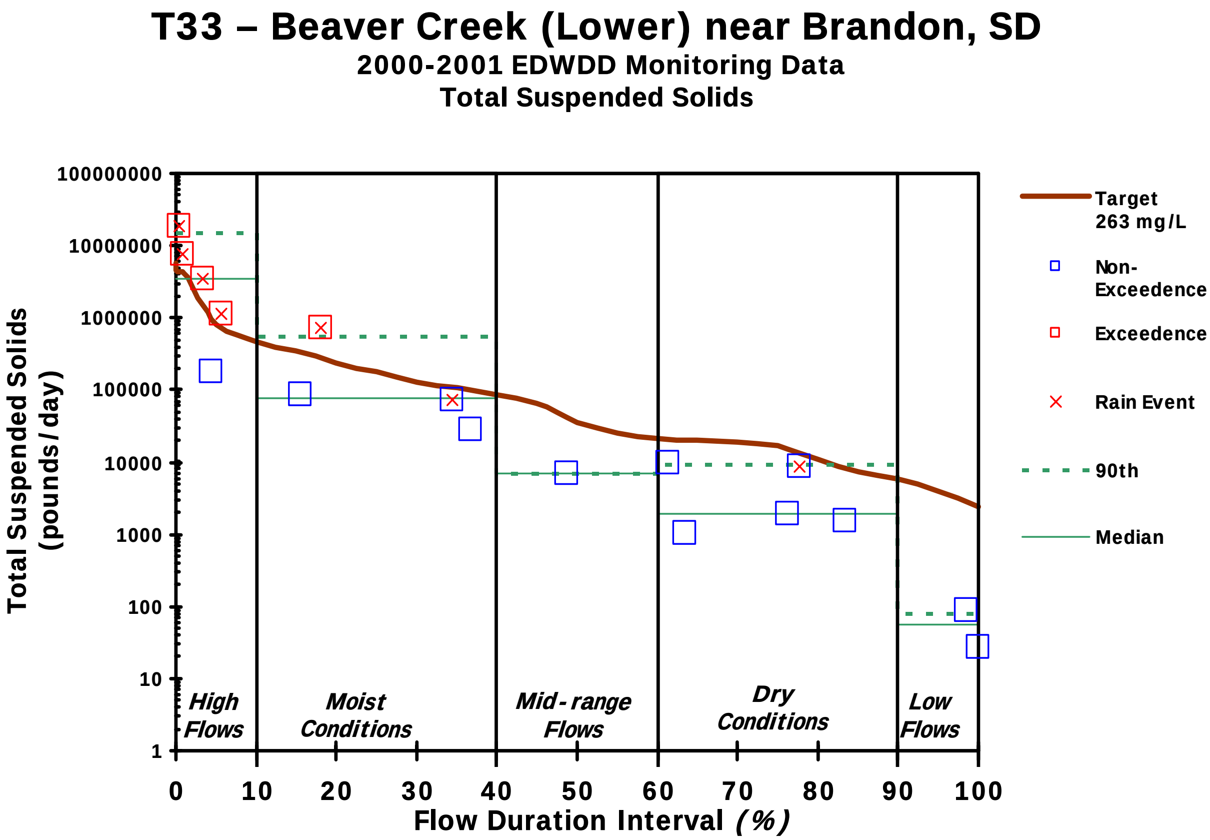
Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	TSS (mg/L)	TSS Load (pounds/day)
T31	06/13/01	1320	2163	0.0049	0.49	972	1.13E+07
T31	04/23/01	1245	436	0.0556	5.56	616	1.45E+06
T31	04/02/01	1245	3204	0.0023	0.23	316	5.46E+06
T31	07/10/00	1330	230	0.0972	9.72	182	2.26E+05

Beaver Creek TSS Reductions at 263 mg/L

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	6.15E+03	6.37E+02	2.72E+02	1.55E+02	2.00E+01
X	Flow Median (cfs)	572.79	123.86	25.52	12.32	2.80
=	Existing	3.52E+06	7.89E+04	6.93E+03	1.91E+03	5.60E+01
	Target Load (at 263 mg/L)	8.13E+05	1.76E+05	3.62E+04	1.75E+04	3.98E+03
	% Reduction w/MOS	79	0	0	0	0

Note: units are pounds/day

		Allowable Loads 263 mg/L	
Flow Rank (percent)	cfs	TSS (pounds/day)	Flow Conditions
0.019	4059.00	5.76E+06	Peak
0.100	3210.87	4.56E+06	
0.274	2998.30	4.26E+06	
1	2889.36	4.10E+06	
5	572.79	8.13E+05	
10	321.50	4.56E+05	
15	241.35	3.43E+05	
20	166.30	2.36E+05	
25	123.86	1.76E+05	
30	91.87	1.30E+05	
35	75.02	1.06E+05	
40	61.03	8.66E+04	
45	44.86	6.37E+04	
50	25.52	3.62E+04	
55	17.85	2.53E+04	
60	15.07	2.14E+04	
65	14.26	2.02E+04	
70	13.12	1.86E+04	
75	12.32	1.75E+04	
80	7.88	1.12E+04	
85	5.05	7.17E+03	
90	4.17	5.92E+03	
95	2.80	3.98E+03	
100	1.68	2.39E+03	Low

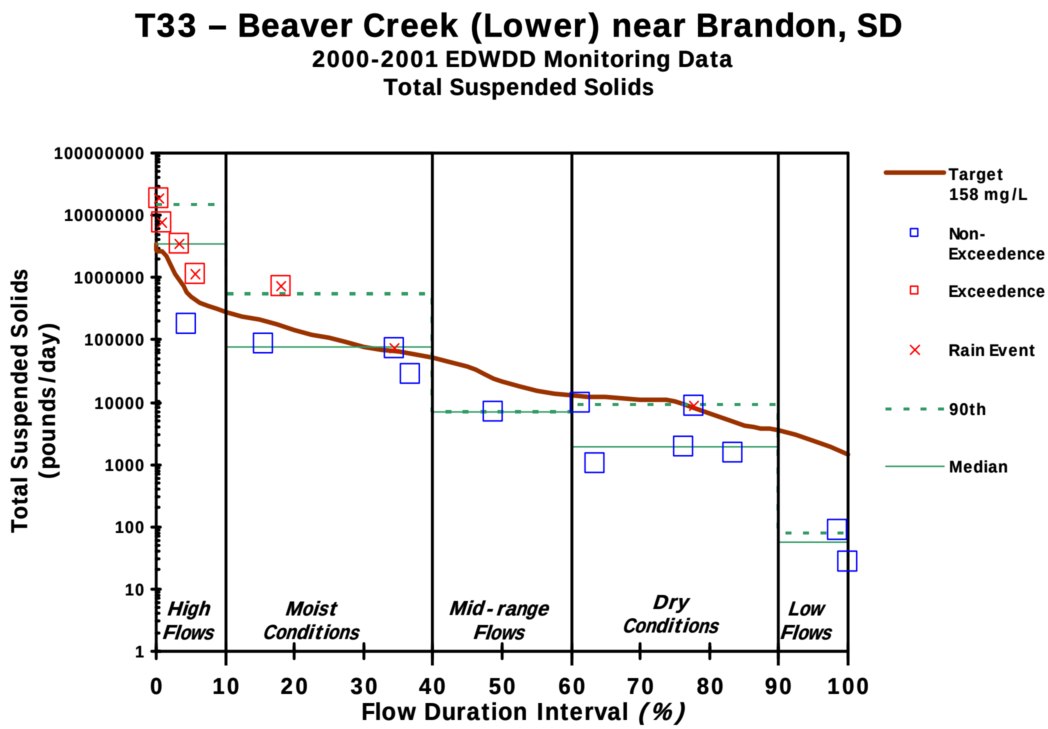

T33 – Beaver Creek (Lower) near Brandon, SD
2000-2001 EDWDD Monitoring Data
Total Suspended Solids
Total Suspended Solids (pounds/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target 263 mg/L
Non-Exceedence
Exceedence
Rain Event
90th
Median

Beaver Creek TSS Reductions at 158 mg/L

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	6.15E+03	6.37E+02	2.72E+02	1.55E+02	2.00E+01
X	Flow Median (cfs)	572.79	123.86	25.52	12.32	2.80
=	Existing	3.52E+06	7.89E+04	6.93E+03	1.91E+03	5.60E+01
	Target Load (at 158 mg/L)	4.88E+05	1.06E+05	2.18E+04	1.05E+04	2.39E+03
	% Reduction w/MOS	87	0	0	0	0

Note: units are pounds/day

		Allowable Loads 158 mg/L	
Flow Rank (percent)	**cfs**	**TSS (pounds/day)**	**Flow Conditions**
0.019	4059.00	3.46E+06	Peak
0.100	3210.87	2.74E+06	
0.274	2998.30	2.56E+06	
1	2889.36	2.46E+06	
5	572.79	4.88E+05	
10	321.50	2.74E+05	
15	241.35	2.06E+05	
20	166.30	1.42E+05	
25	123.86	1.06E+05	
30	91.87	7.83E+04	
35	75.02	6.40E+04	
40	61.03	5.20E+04	
45	44.86	3.82E+04	
50	25.52	2.18E+04	
55	17.85	1.52E+04	
60	15.07	1.29E+04	
65	14.26	1.22E+04	
70	13.12	1.12E+04	
75	12.32	1.05E+04	
80	7.88	6.72E+03	
85	5.05	4.31E+03	
90	4.17	3.56E+03	
95	2.80	2.39E+03	
100	1.68	1.44E+03	Low

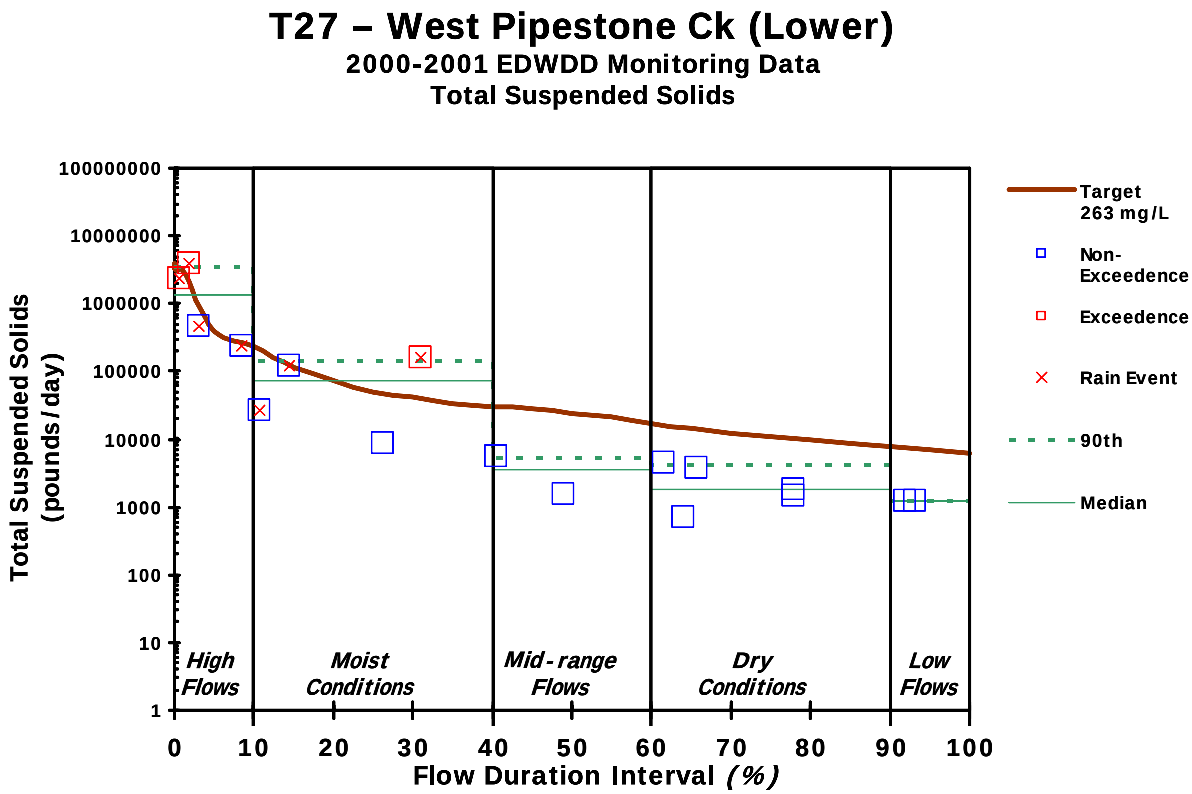

T33 – Beaver Creek (Lower) near Brandon, SD
2000-2001 EDWDD Monitoring Data
Total Suspended Solids
Total Suspended Solids (pounds/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target 158 mg/L
Non-Exceedence
Exceedence
Rain Event
90th
Median

West Pipestone Creek TSS Reductions at 263 mg/L

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	5.09E+03	2.16E+03	2.17E+02	2.40E+02	2.51E+02
X	Flow Median (cfs)	270.88	34.39	16.66	7.63	4.96
=	Existing	1.38E+06	7.44E+04	3.61E+03	1.83E+03	1.24E+03
	Target Load (at 263 mg/L)	3.84E+05	4.88E+04	2.36E+04	1.08E+04	7.04E+03
	% Reduction w/MOS	75	40	0	0	0

Note: units are pounds/day

		Allowable Loads 263 mg/L	
Flow Rank (percent)	cfs	TSS (pounds/day)	Flow Conditions
0.019	2772.29	3.93E+06	Peak
0.100	2350.22	3.34E+06	
0.274	2212.97	3.14E+06	
1	2180.82	3.09E+06	
5	270.88	3.84E+05	
10	169.40	2.40E+05	
15	78.57	1.12E+05	
20	52.18	7.40E+04	
25	34.39	4.88E+04	
30	28.70	4.07E+04	
35	23.16	3.29E+04	
40	21.12	3.00E+04	
45	19.68	2.79E+04	
50	16.66	2.36E+04	
55	14.96	2.12E+04	
60	12.26	1.74E+04	
65	10.30	1.46E+04	
70	8.73	1.24E+04	
75	7.63	1.08E+04	
80	6.87	9.75E+03	
85	6.06	8.60E+03	
90	5.51	7.82E+03	
95	4.96	7.04E+03	
100	4.41	6.25E+03	Low



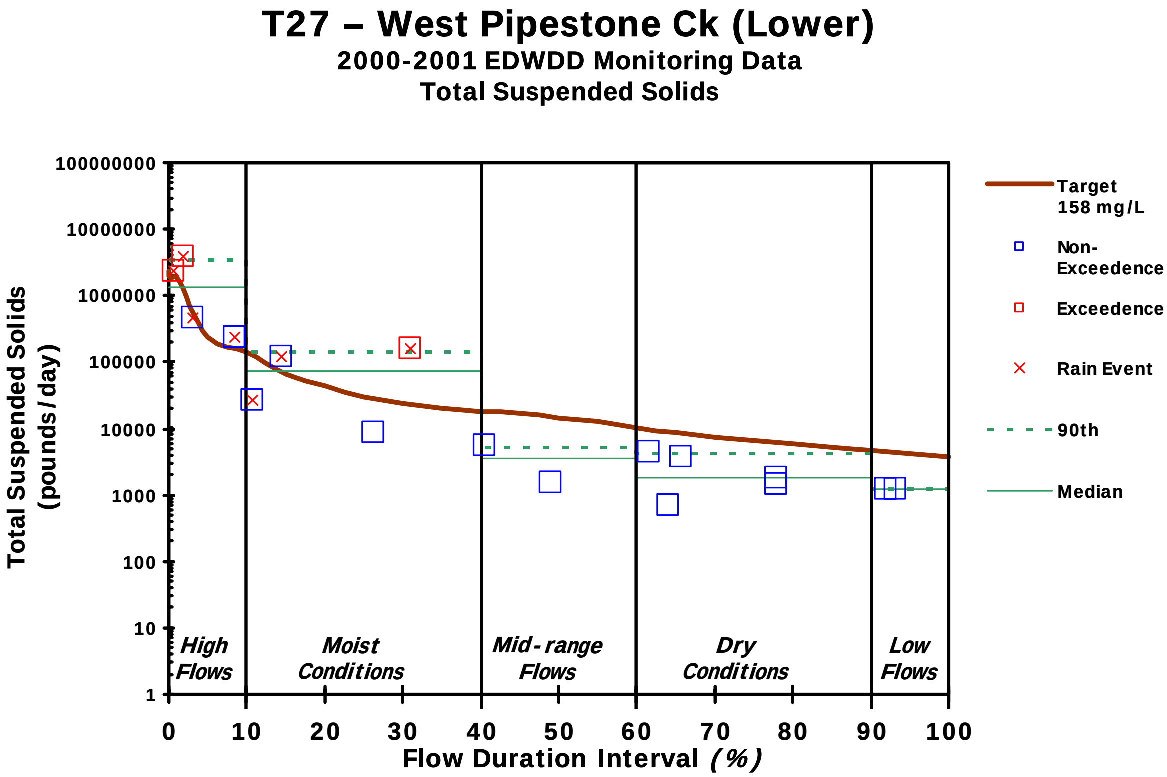
T27 – West Pipestone Ck (Lower)
2000-2001 EDWDD Monitoring Data
Total Suspended Solids
Total Suspended Solids (pounds/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target 263 mg/L
Non-Exceedence
Exceedence
Rain Event
90th
Median

West Pipestone Creek TSS Reductions at 158 mg/L

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	5.09E+03	2.16E+03	2.17E+02	2.40E+02	2.51E+02
X	Flow Median (cfs)	270.88	34.39	16.66	7.63	4.96
=	Existing	1.38E+06	7.44E+04	3.61E+03	1.83E+03	1.24E+03
	Target Load (at 158 mg/L)	2.31E+05	2.93E+04	1.42E+04	6.51E+03	4.23E+03
	% Reduction w/MOS	85	64	0	0	0

Note: units are pounds/day

		Allowable Loads 158 mg/L	
Flow Rank (percent)	cfs	TSS (pounds/day)	Flow Conditions
0.019	2772.29	2.36E+06	Peak
0.100	2350.22	2.00E+06	
0.274	2212.97	1.89E+06	
1	2180.82	1.86E+06	
5	270.88	2.31E+05	
10	169.40	1.44E+05	
15	78.57	6.70E+04	
20	52.18	4.45E+04	
25	34.39	2.93E+04	
30	28.70	2.45E+04	
35	23.16	1.97E+04	
40	21.12	1.80E+04	
45	19.68	1.68E+04	
50	16.66	1.42E+04	
55	14.96	1.28E+04	
60	12.26	1.05E+04	
65	10.30	8.78E+03	
70	8.73	7.45E+03	
75	7.63	6.51E+03	
80	6.87	5.86E+03	
85	6.06	5.17E+03	
90	5.51	4.70E+03	
95	4.96	4.23E+03	
100	4.41	3.76E+03	Low


T27 – West Pipestone Ck (Lower)
2000-2001 EDWDD Monitoring Data
Total Suspended Solids
Total Suspended Solids (pounds/day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target 158 mg/L
Non-Exceedence
Exceedence
Rain Event
90th
Median

Appendix BBB.
TMDL – Split Rock Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Split Rock Creek
(within South Dakota)

(HUC 10170203)

Minnehaha County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Split Rock Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-SPLIT_ROCK_01_USGS
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Semi-permanent Fish Life Propagation Immersion Recreation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Stream:	28.0 miles (within South Dakota)
Size of Watershed:	168,728 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Immersion Recreation Beneficial Use during the months of May through September
Target:	≤ 400 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Split Rock Creek is a 28.0 mile segment (within South Dakota) with a watershed of approximately 168,728 acres, which includes LMUs 26, 27, 28, 29, 30, 31, 33, Z, DD, and GG. Split Rock Creek is a tributary to the Big Sioux River (HUC 10170203) in southeastern Minnehaha County, South Dakota. This segment's watershed lies within Moody and Minnehaha Counties as shown by the shaded region in Figure 1. This tributary is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1. Split Rock Creek is listed in the 2006 Integrated Report as unknown for its support of warmwater semipermanent fish life propagation, and immersion recreation uses.

Split Rock Creek is influenced by the tributaries of West Pipestone Creek, Pipestone Creek, and Beaver Creek. The Central Big Sioux River Watershed Assessment Project has identified Split Rock Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Appendix B of the Assessment Report summarizes the data collected during the Central Big Sioux River Watershed Assessment Project from June 2000 to September 2001.

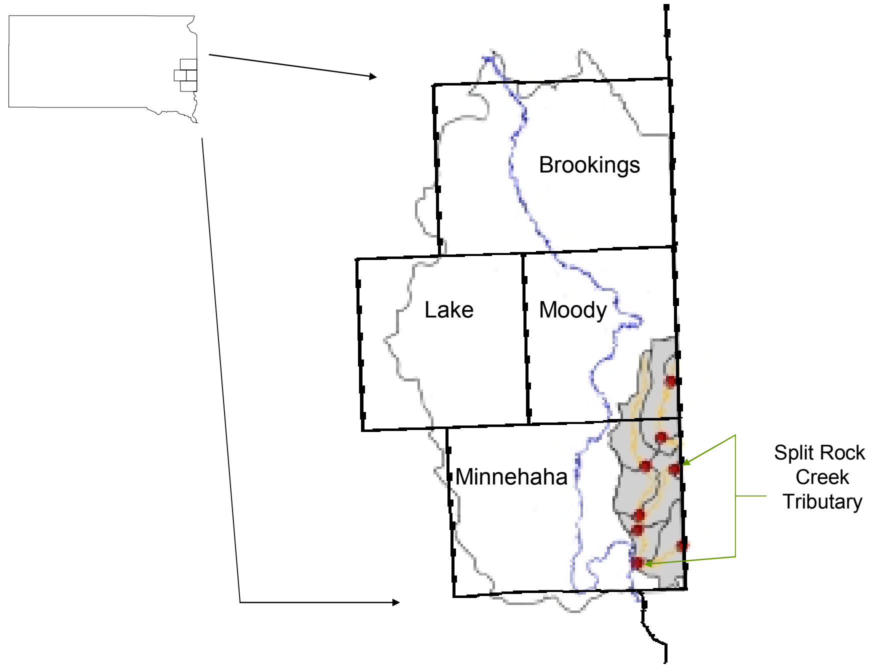


Figure 1. Location of the Split Rock Creek Watershed in South Dakota

Problem Identification

Although Split Rock Creek begins in Minnesota, the Central Big Sioux River Watershed Assessment evaluated only the portion within South Dakota. This portion begins at monitoring site T30, until it joins the Big Sioux River below monitoring site T33, near the City of Brandon. The watershed area shown in Figure 2 drains approximately 99 percent grass/grazing land and cropland acres. This includes the receiving waters of West Pipestone Creek (Sites T26 and T27), Pipestone Creek (Sites T28 and T29), and Beaver Creek (Sites T32 and T33). The municipalities of Brandon, Sherman, Corson, Garretson, and Valley Springs are located in this area. The municipalities of Jasper, Ihlen, and Pipestone in Minnesota may also be influencing this stream.

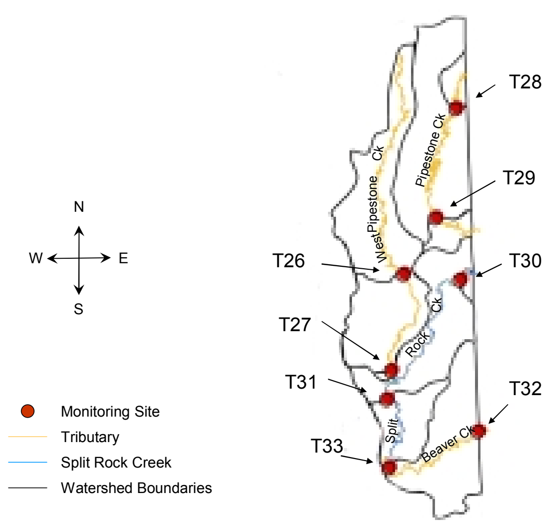


Figure 2. Split Rock Creek Watershed

Split Rock Creek was found to carry fecal coliform bacteria which degrades water quality. This tributary is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 400 counts per 100 milliliters for fecal coliform bacteria. This creek requires reducing the fecal coliform counts per day in overall hydrologic conditions. Table 1 displays the fecal coliform data collected from June 2000 to September 2000 and from May 2001 to September 2001.

Table 1. Summary of Fecal Coliform Data for Split Rock Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 400 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	22	91	400	137,000

A total of 22 water quality samples were taken from monitoring locations T30 and T31 of Split Rock Creek. Of these 22 samples, 20 (or 91 percent) were violating the water quality standards. This 91 percent indicates that this tributary is not meeting the water quality criteria for its beneficial uses.

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Split Rock Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Warmwater semipermanent fish propagation
- Immersion recreation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. The tributaries flowing into Split Rock Creek have been assigned a range of beneficial uses with the designated numeric and narrative standards as shown by the shaded areas in Table 2.

Table 2. Monitoring Sites and Their Beneficial Use Classification

	Tributaries							
Creek Name	W. Pipestone		Pipestone		Split Rock		Beaver	
Beneficial Uses	T26	T27	T28	T29	T30	T31	T32	T33
Warmwater Semipermanent Fish Life Propagation								
Warmwater Marginal Fish Life Propagation								
Immersion Recreation								
Limited Contact Recreation								
Fish & Wildlife Propagation Recreation & Stock Watering								
Irrigation								

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation and immersion recreation involved monitoring the levels of fecal coliform from May 1 through September 30. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. This creek experiences fecal coliform loading due to absent or poor riparian areas, NPDES facilities, stormwater, pastured livestock, manure/feedlot runoff, and urban runoff.

Split Rock Creek was evaluated using the more stringent numeric standard of ≤ 400 cfu/100mL. Results show that this stream is not supporting for its immersion recreation beneficial use. Further analysis shows that this stream is not supporting of its limited contact recreation beneficial use even when the ≤ 2,000 cfu/100mL numeric standard is applied. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedances occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent).

Since 91 percent of the samples were exceeding the numeric standard and there were >5 samples in at least three flowzones, a more conservative approach for calculating reductions was used. All flowzones were combined to assess the "overall" fecal coliform bacteria problem. The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

Two monitoring locations, T30 and T31, were installed on Split Rock Creek. Of the 22 water samples that were collected, 20 (or 91 percent) violated the water quality standards for fecal coliform bacteria at the ≤ 400 cfu/100mL standard. Based on the water quality violations, this waterbody is currently not supporting its immersion recreation beneficial use (Appendix FF, Assessment Report).

Each of the tributaries flowing into Split Rock Creek were also assessed for fecal coliform loading levels. Pipestone Creek (Sites T28 and T29) and Beaver Creek (Sites T32 and T33) are two, of the three tributaries, with an assigned numeric standard for fecal coliform bacteria. However, all tributaries were assessed at the ≤ 400 cfu/100mL numeric standard. Table 3 displays the fecal coliform data collected from June 2000 to September 2000 and from May 2001 to September 2001.

Table 3. Summary of Fecal Data for Tributaries Within the Split Rock Creek Watershed

Monitoring Location	Number of Samples (May-Sep)	Percent of Samples > 400 counts/100mL	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
* West Pipestone Creek	21	66.7	42.9	60	64,000
Pipestone Creek	22	86.4	27.3	310	25,000
** Beaver Creek	22	90.9	40.9	120	172,000

* numeric standard does not apply ** currently assigned a numeric standard of 2000 cfu/100mL

Pipestone Creek (Sites T28 and T29) is currently not supporting its assigned beneficial uses at the current numeric standard of ≤ 400 cfu/100mL for fecal coliform bacteria. Of the 22 samples that were taken, 19 (86.4 percent) violated the water quality standards. A separate TMDL for

Pipestone Creek has been initiated. It is expected the TMDL for Pipestone Creek will satisfy the requirements of this TMDL in regards to the load it is contributing to Split Rock Creek.

Beaver Creek (Sites T32 and T33) is not supporting its assigned beneficial uses at its current numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. Since this tributary directly joins Split Rock Creek, it is assumed the excess fecal coliform bacteria has a significant effect on the fecal coliform concentrations of Split Rock Creek. Of the 22 samples, 9 (or 40.9 percent) violated the water quality standards at 2,000 cfu/100mL. A separate TMDL for Beaver Creek has been initiated. It is expected the TMDL for Beaver Creek will satisfy the requirements of this TMDL in regards to the load it is contributing to Split Rock Creek. If this TMDL is insufficient in correcting the fecal colform bacteria problem, a more stringent standard may need to be applied to the Beaver Creek tributary in order to meet the downstream goals of Split Rock Creek (See Rule 74:51:01:04 below).

West Pipestone Creek (Sites T26 and T27) is not assigned a numeric standard for fecal coliform bacteria. However, this creek was evaluated at the ≤ 400 cfu/100mL numeric standard. Of the 21 water quality samples that were collected, 14 (or 67 percent) violated the water quality standards for fecal coliform bacteria.

An improvement to the fecal coliform load in these tributaries is necessary to meet the goals of this TMDL. According to Rule **74:51:01:04 Application of criterion to contiguous water** states,

> *"If pollutants are discharged into a segment and the criteria for that segments designated beneficial use are not exceeded but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, that pollutants may not cause the more stringent criteria to be exceeded."*

If one body of water runs into another body of water with a more stringent standard, the more stringent standard would apply to all waters of concern. In this case, Split Rock Creek is assigned a numeric standard of ≤ 400 cfu/100mL. In order to meet the goals for Split Rock Creek, all received waters must also meet the ≤ 400 cfu/100mL numeric criteria for fecal coliform bacteria according to Rule 74:51:01:04 (Figure 3). Therefore, both West Pipestone Creek and Beaver Creek should be evaluated at a numeric standard of ≤ 400 cfu/100mL and their fecal coliform loadings reduced accordingly. It is possible that once the Beaver Creek TMDL is met, it will also satisfy the goals of this TMDL. However, Beaver Creek may need to be re-assessed at the ≤ 400 cfu/100mL numeric standard to ensure it is also meeting the goals of Split Rock Creek.

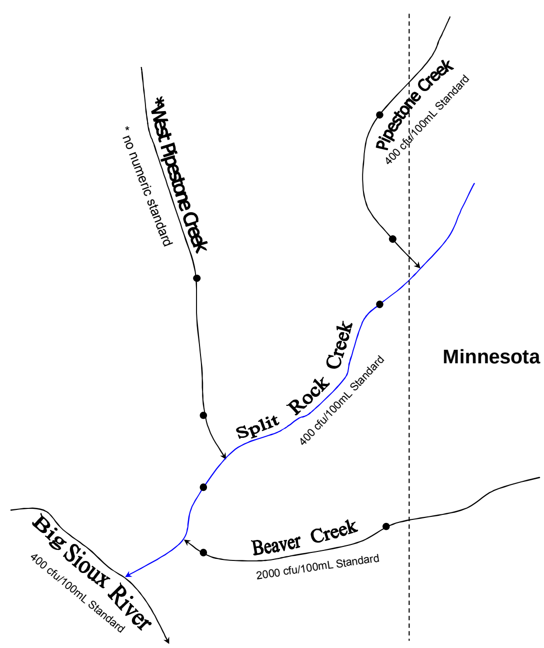


Figure 3. Water Flow of the Tributaries Affecting Split Rock Creek

Pollutant Assessment

Point Sources

NPDES facilities taken into consideration within this area include the USGS-EROS Data Center, the City of Garretson, the Corson Village Sanitary District, and the City of Valley Springs (Table 4). Total contribution from these facilities during the study period was zero, due to either the facility not discharging or fecal coliform data not being recorded. The potential load from the facilities is shown in Table 4.

Table 4. NPDES Facilities.

Facility Name	Permit Number	# colonies/day
Valley Springs (WWTP)	SD0020923	4.01E+10
Corson (WWTP)	SD0022217	0
EROS (WWTP)	SD0000299	4.00E+10
Garrestson (WWTP)	SD0022560	0

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 5.

Table 5. Livestock Distribution for the Split Rock Creek Watershed

Livestock Distribution	W. Pipestone	Pipestone	Split Rock	Beaver
Beef Cattle/Calves	6611	4570	2287	1931
Hogs/Pigs	1797	400	-----	1000
Dairy Cattle	705	150	225	230
Sheep	-----	100	-----	-----

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 6 shows that 99 percent of the area is grass or cropland. Urban areas would fall into the artificial category, which makes up approximately one percent of the watershed.

Table 6. Landuse in the Split Rock Creek Watershed

LandUse	Percent	Acres
Water	0%	169
Trees	1%	1,012
Artificial	1%	844
Barren	0%	169
Grass	22%	36,783
LEP Cropland	56%	94,319
MEP Cropland	10%	17,548
HEP Cropland	11%	17,885

LEP = Low Erosion Potential

MEP = Medium Erosion Potential

HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at two monitoring sites on Split Rock Creek and six additional sites from the entering tributaries. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.
The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) × (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria in this tributary, the range of flows from each of the monitoring locations were merged to form the flow duration interval curve and were then divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-range (40-60), Dry (60-90), and Low (90-100). For this tributary, the overall condition of the hydrologic zones was evaluated. Excessive fecal coliform loadings are mainly occurring during mid-range to high flow conditions. Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 4, any sample occurring above this line is an exceedence of the water quality standard and is represented by a red box See Attachment 1 for details). Table 7 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow. Flow duration interval graphs and fecal exceedence tables were also constructed for West Pipestone Creek (Attachment 2), Pipestone Creek (Attachment 3), and Beaver Creek (Attachment 4).

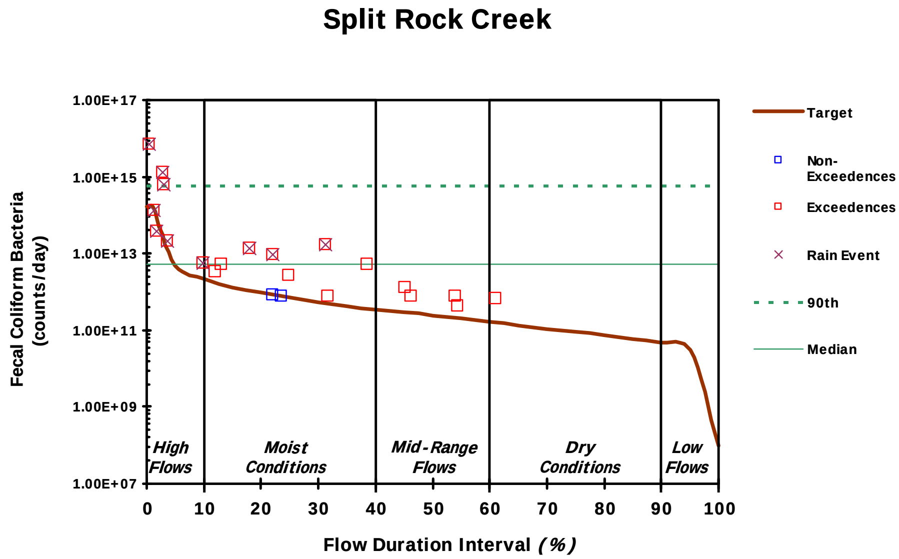


Figure 4. Flow Duration Interval for Split Rock Creek

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze current feedlots and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agriculture related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 8 shows how many of the feedlots and in which LMU the 69 feedlots that rated 50 or greater were identified. A rating of 50 or greater warrants concern in regards to potential pollution problems (See Attachment 5 for a more detailed table). A map identifying those regions of concern is shown in Figure 5. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 7. Fecal Coliform Target Loads for Flow

Flow Rank (percent)	cfs	Allowable Loads 400 cfu/100mL: Fecal Coliform (counts/day)	Flow Conditions
0.019	17324.95	1.70E+14	Peak
0.100	16624.00	1.63E+14	
0.274	16464.00	1.61E+14	
1	16400.00	1.61E+14	
5	500.60	4.90E+12	
10	224.00	2.19E+12	
15	133.80	1.31E+12	
20	96.00	9.40E+11	
25	72.00	7.05E+11	
30	55.98	5.48E+11	
35	44.00	4.31E+11	
40	35.00	3.43E+11	
45	30.00	2.94E+11	
50	25.00	2.45E+11	
55	21.00	2.06E+11	
60	17.00	1.66E+11	
65	14.00	1.37E+11	
70	11.00	1.08E+11	
75	9.40	9.20E+10	
80	7.70	7.54E+10	
85	6.20	6.07E+10	
90	4.80	4.70E+10	
95	3.00	2.94E+10	
100	0.01	9.79E+07	Low

Table 8. Feedlot Ratings ≥ 50 for Spring Creek Watershed

LMU	# of feedlots rating ≥ 50
26	nine
27	three
28	two
29	seven
31	seven
33	five
GG	three
Z	one

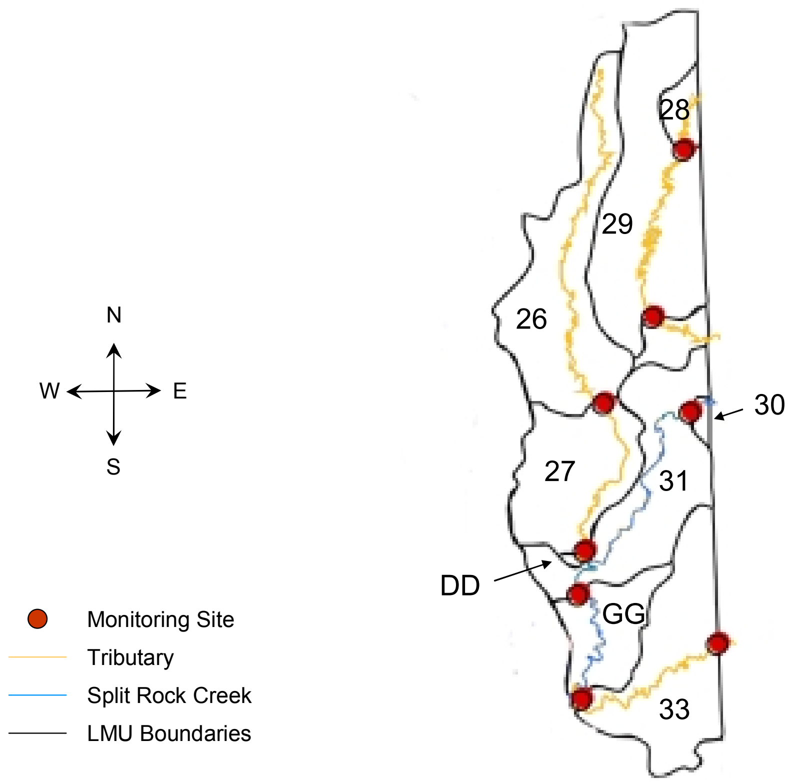


Figure 5. LMUs of the Split Rock Creek Watershed

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)
			Overall
SD-BS-R-SPLIT_ROCK_01_USGS		TMDL	2.45E+11
		10% MOS	2.45E+10
		Total Allocations	2.21E+11
		LA	1.40E+11
	Valley Springs (WWTP)	WLA	4.01E+10
	Corson (WWTP)	WLA	0
	EROS (WWTP)	WLA	4.00E+10
	Garrestson (WWTP)	WLA	0
		Background	2.81E+09
		Other NPS	1.38E+11

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 8.01×10^{10} fecal counts if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this tributary will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, reductions are needed from non-point sources, mainly during moist to high flows conditions (refer to Figure 4), as shown in the implementation section.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Both monitoring sites (T30 and T31) have exhibited exceedances of the water quality criteria for fecal coliform bacteria. Of the samples taken that were exceeding the standard (≤ 400 cfu/100mL), 50 percent occurred during rain events (See Appendix B of the Assessment Report for EDWDD samples).

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameters of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to increase public awareness to educate, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Split Rock Creek TMDL.

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classification of this stream. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural and municipal BMPs to reduce loads during moist conditions and runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from the overall flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 96 percent for under all flow conditions (Table 9). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 9. Split Rock Creek Fecal Coliform Reductions

	Median	**Overall (0-100)**
	Median Concentration (counts/day)	2.10E+11
X	Flow Median (cfs)	25
=	Existing	5.26E+12
	Target Load (at 400 cfu/100mL)	2.45E+11
	% Reduction w/MOS	96

Note: units are counts/day

Using the individual flowzones results in two flowzones with no samples and no reductions. A more conservative approach using the overall conditions was taken to aid implementation efforts after the entire landuse data and size of the watershed was considered. The following table shows the reductions for individual flowzones (Table 10).

Table 10. Split Rock Creek Fecal Coliform Reductions by Zone

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low (90-100)
	Median Concentration (counts/day)	2.66E+11	6.00E+10	3.07E+10	7.01E+10	------
X	Flow Median (cfs)	500.6	72	25	9.4	3
=	Existing	1.33E+14	4.32E+12	7.67E+11	6.59E+11	------
	Target Load (at 400 cfu/100mL)	4.90E+12	7.05E+11	2.45E+11	9.20E+10	2.94E+10
	% Reduction w/MOS	97	85	71	87	------
	number of samples per zone =	7	10	4	1	0

Note: units are counts/day

Each of the tributary flowing into Split Rock Creek was assessed for fecal coliform loadings. Pipestone Creek (Sites T28 and T29) and Beaver Creek (Sites T32 and T33) are two, of the three tributaries, with an assigned numeric standard for fecal coliform bacteria. However, all tributaries were assessed at the ≤ 400 cfu/100mL numeric standard.

Pipestone Creek (Sites T28 and T29) is currently not supporting its assigned beneficial uses at the current numeric standard of ≤ 400 cfu/100mL for fecal coliform bacteria. At ≤ 400 cfu/100mL, Pipestone Creek would need an 89 percent reduction during high flows/moist conditions and an 87 percent reduction during dry conditions/low flows (Table 11). A separate TMDL for Pipestone Creek has been initiated. It is expected the TMDL for Pipestone Creek will satisfy the requirements of this TMDL in regards to the load it is contributing to Split Rock Creek.

Table 11. Fecal Coliform Bacteria Reductions for Pipestone Creek

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry (60-90)
	Median Concentration (counts/day)	8.05E+10	8.42E+09	7.06E+10
X	Flow Median (cfs)	75.20	36.92	11.29
=	Existing	6.05E+12	3.11E+11	7.97E+11
	Target Load (at 400 cfu/100mL)	7.36E+11	3.61E+11	1.10E+11
	% Reduction w/MOS	89	0	87

Note: units are counts/day

Beaver Creek (Sites T32 and T33) is not supporting its assigned beneficial uses at its current numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. At the currently assigned standard, Beaver Creek requires a reduction of 86 percent during high flows/moist conditions (Table 12). A separate TMDL for Beaver Creek has been initiated. It is expected the TMDL for Beaver Creek will satisfy the requirements of this TMDL in regards to the load it is contributing to Split Rock Creek. If this TMDL is insufficient in correcting the fecal colform bacteria problem, a more stringent standard may need to be applied to the Beaver Creek tributary in order to meet the downstream goals of Split Rock Creek.

Table 12. Fecal Coliform Bacteria Reduction for Beaver Creek

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry/Low (60-100)
	Median Concentration (counts/day)	2.37E+11	2.41E+10	2.05E+10
X	Flow Median (cfs)	155.5	25.31	6.05
=	Existing	3.68E+13	6.10E+11	1.24E+11
	Target Load (at 2,000 cfu/100mL)	5.65E+12	1.24E+12	2.96E+11
	% Reduction w/MOS	86	0	0
Note: units are counts/day				

West Pipestone Creek (Sites T26 and T27) is not assigned a numeric standard for fecal coliform bacteria. However, this creek was evaluated at the ≤ 400 cfu/100mL numeric standard. At ≤ 400 cfu/100mL, West Pipestone Creek would need a 99 percent reduction during high/moist conditions, a 91 percent reduction at mid-range flows, and an 84 percent reduction during dry/low flows (Table 13).

Table 13. Fecal Coliform Bacteria Reduction for West Pipestone Creek

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry/Low (60-100)
	Median Concentration (counts/day)	2.29E+11	4.62E+10	1.75E+10
X	Flow Median (cfs)	155.5	25.31	6.05
=	Existing	3.56E+13	1.17E+12	1.06E+11
	Target Load (at 400 cfu/100mL)	5.68E+11	1.15E+11	1.85E+10
	% Reduction w/MOS	99	91	84
Note: units are counts/day				

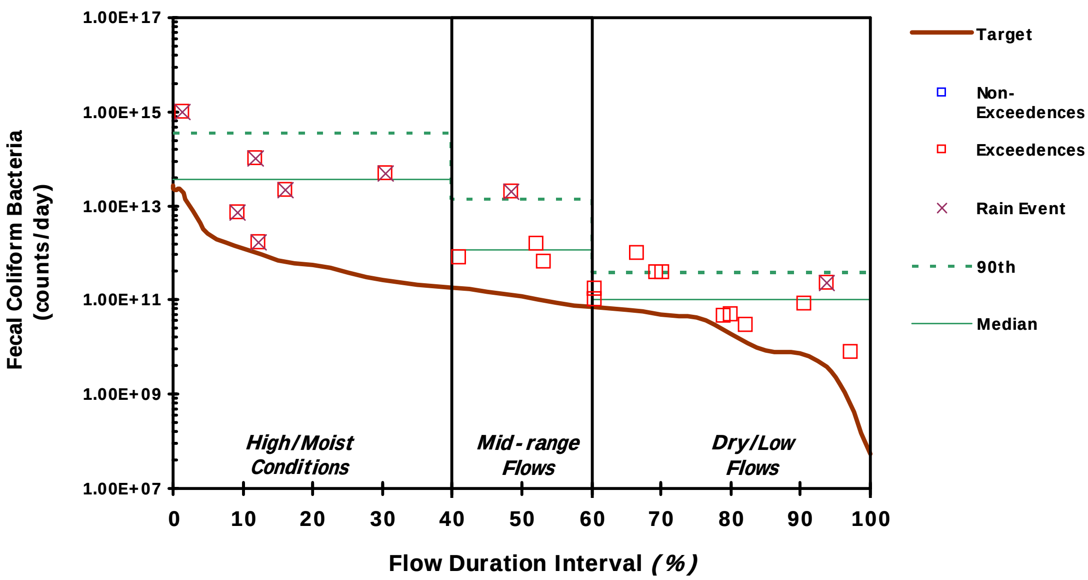
Fecal Exceedences for Split Rock Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T31	06/13/01	1320	2162.90	0.0052	0.52	137000	7.25E+15
T31	07/23/01	1215	751.70	0.0281	2.81	69000	1.27E+15
T30	06/13/01	1120	714.96	0.0308	3.08	36000	6.30E+14
T30	07/10/00	1130	52.83	0.312	31.2	13000	1.68E+13
T30	09/19/00	1115	38.29	0.3848	38.48	5500	5.15E+12
T30	07/23/01	1045	109.60	0.1797	17.97	5100	1.37E+13
T30	06/13/00	1430	1207.35	0.0128	1.28	4500	1.33E+14
T31	06/14/00	1415	86.00	0.2196	21.96	4400	9.26E+12
T30	08/14/01	1030	29.69	0.4515	45.15	1800	1.31E+12
T31	05/07/01	1210	979.15	0.0181	1.81	1600	3.83E+13
T31	09/19/00	1345	16.84	0.6109	61.09	1600	6.59E+11
T31	08/14/01	1200	72.66	0.2488	24.88	1500	2.67E+12
T31	07/09/01	1245	156.85	0.1312	13.12	1400	5.37E+12
T30	09/11/01	1030	22.08	0.5388	53.88	1400	7.56E+11
T30	05/07/01	1110	648.39	0.0357	3.57	1300	2.06E+13
T31	08/16/00	1300	28.89	0.4625	46.25	1100	7.78E+11
T31	07/10/00	1330	229.55	0.0984	9.84	1000	5.62E+12
T31	06/05/01	1230	177.52	0.1205	12.05	800	3.48E+12
T30	08/16/00	1130	21.68	0.5444	54.44	800	4.24E+11
T31	09/11/01	1215	51.31	0.3173	31.73	600	7.53E+11

Fecal Exceedences and Flow Duration Interval for West Pipestone Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T27	7/23/2001	1110	27.324	0.3038	30.38	74000	4.95E+13
T26	7/23/2001	1100	12.717	0.4855	48.55	64000	1.99E+13
T27	6/13/2001	1200	658.046	0.0120	1.20	61000	9.82E+14
T27	7/10/2000	1230	92.347	0.1184	11.84	45000	1.02E+14
T26	7/10/2000	1100	0.361	0.9382	93.82	27000	2.38E+11
T26	6/13/2001	1100	63.175	0.1612	16.12	14000	2.16E+13
T26	6/13/2000	1500	5.855	0.6645	66.45	7100	1.02E+12
T27	9/19/2000	1210	10.946	0.5210	52.10	5800	1.55E+12
T26	9/11/2001	1045	0.752	0.9052	90.52	4400	8.10E+10
T26	8/16/2000	1115	0.100	0.9713	97.13	3300	8.11E+09
T27	6/14/2000	1330	5.181	0.7020	70.20	3000	3.80E+11
T27	8/16/2000	1210	5.286	0.6938	69.38	2900	3.75E+11
T27	7/9/2001	930	10.226	0.5331	53.31	2500	6.26E+11
T27	5/7/2001	1130	152.752	0.0919	9.19	1900	7.10E+12
T27	6/5/2001	1115	17.762	0.4105	41.05	1800	7.82E+11
T26	7/9/2001	1045	1.802	0.8010	80.10	1100	4.85E+10
T26	8/14/2001	1045	1.139	0.8229	82.29	1100	3.06E+10
T27	8/14/2001	1115	7.215	0.6061	60.61	1000	1.77E+11
T26	5/7/2001	1045	83.821	0.1226	12.26	800	1.64E+12
T26	6/5/2001	1040	2.674	0.7905	79.05	700	4.58E+10
T27	9/11/2001	1115	7.215	0.6061	60.61	600	1.06E+11

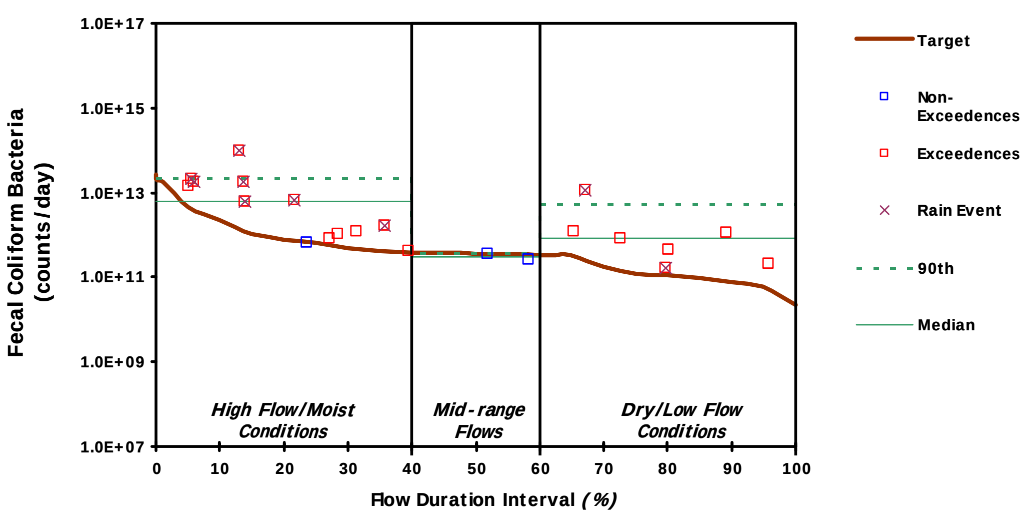
West Pipestone Creek @ 400 cfu/100mL



Fecal Exceedences and Flow Duration Interval for Pipestone Creek

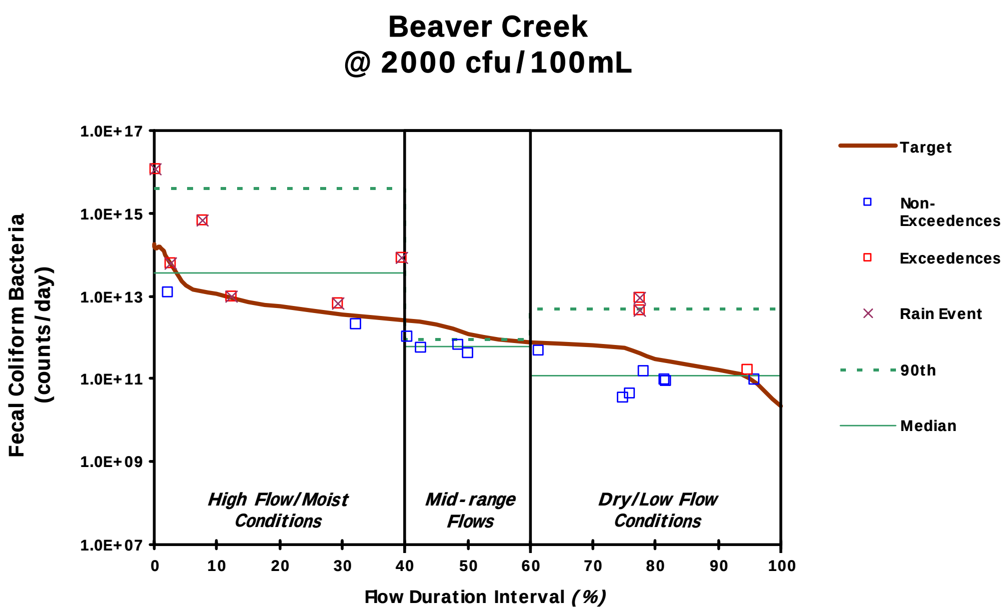
Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T28	06/13/01	900	161.16	0.1298	12.98	25000	9.86E+13
T28	07/23/01	930	26.68	0.6712	67.12	17000	1.11E+13
T28	08/15/00	1545	7.71	0.8924	89.24	6000	1.13E+12
T29	06/13/01	1000	142.00	0.1364	13.64	5000	1.74E+13
T29	07/23/01	1030	69.64	0.2154	21.54	4000	6.82E+12
T28	08/14/01	930	13.57	0.7262	72.62	2400	7.97E+11
T29	05/07/01	1015	446.27	0.0542	5.42	1900	2.07E+13
T28	06/13/00	1315	137.44	0.1392	13.92	1800	6.05E+12
T28	05/07/01	940	412.91	0.0603	6.03	1800	1.82E+13
T28	09/11/01	930	11.13	0.8015	80.15	1600	4.36E+11
T29	07/10/00	1030	41.95	0.3582	35.82	1600	1.64E+12
T29	09/19/00	1030	33.42	0.6526	65.26	1500	1.23E+12
T28	09/19/00	1000	6.05	0.958	95.8	1400	2.07E+11
T29	06/13/00	1345	465.65	0.0518	5.18	1300	1.48E+13
T28	06/05/01	945	48.15	0.3145	31.45	1000	1.18E+12
T28	07/09/01	1000	54.10	0.2841	28.41	800	1.06E+12
T28	07/10/00	950	11.38	0.7978	79.78	580	1.62E+11
T29	07/09/01	1030	59.16	0.2709	27.09	560	8.11E+11
T29	08/14/01	1000	39.66	0.396	39.6	420	4.08E+11

Pipestone Creek @ 400 cfu/100mL



Fecal Exceedences and Flow Duration Interval for Beaver Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Coliform Load (counts/day)
T33	06/13/01	1445	2678.52	0.0025	0.25	172000	1.12735E+16
T32	06/13/01	1400	278.33	0.0767	7.67	96000	6.53839E+14
T32	07/23/01	1300	53.77	0.3962	39.62	65000	8.55292E+13
T33	07/10/00	1450	9.68	0.7748	77.48	37000	8.77E+12
T32	07/10/00	1430	9.22	0.7756	77.56	20000	4.51E+12
T33	05/07/01	1400	566.66	0.0275	2.75	4400	6.10E+13
T33	07/23/01	1315	76.40	0.2947	29.47	3400	6.36E+12
T33	09/19/00	1500	2.28	0.9475	94.75	2900	1.61E+11
T32	05/07/01	1330	190.38	0.1235	12.35	2100	9.78E+12



Feedlot Rating by LMU

LMU	Feedlot Rating
26	50
26	58
26	61
26	64
26	64
26	65
26	68
26	71
26	76
27	57
27	63
27	92
28	54
28	56
29	53
29	54
29	55
29	56

LMU	Feedlot Rating
29	59
29	66
29	74
31	59
31	61
31	64
31	66
31	68
31	70
31	78
33	50
33	51
33	55
33	58
33	64
GG	53
GG	54
GG	74
Z	50

Appendix CCC.
TMDL – Beaver Creek (TSS)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Total Suspended Solids)

for

Beaver Creek
(within South Dakota)

(HUC 10170203)

Minnehaha County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Beaver Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-BEAVER_02
303(d) Listing Parameter:	Suspended Solids
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Stream:	17.1 miles (within South Dakota)
Size of Watershed:	39,548 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Models including Flow Duration Interval Zones and the Sediment Delivery Model (SDM)
Location:	HUC Code: 10170203
Goal:	Full Support of the Warmwater Marginal Fish Life Propagation Beneficial Use
Target:	≤ 263 mg/L of total suspended solids (any one sample)

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Beaver Creek is a 17.1 mile portion of tributary with a watershed (LMUs 33 and GG) of approximately 39,548 acres (within South Dakota). Beaver Creek is a tributary to Split Rock Creek (HUC 10170203) in southeastern Minnehaha County in South Dakota. This watershed lies within Minnehaha County as shown by the shaded region in Figure 1. This watershed is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

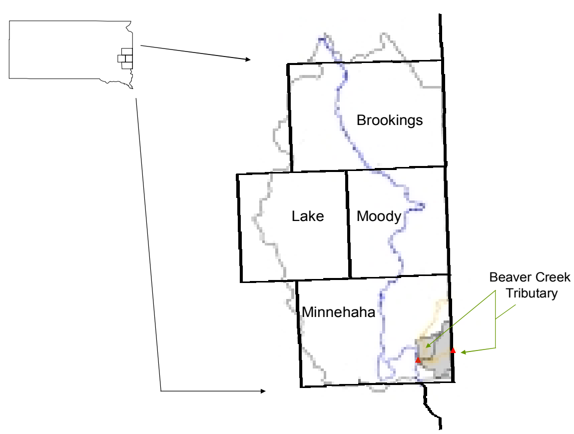


Figure 1. Location of Beaver Creek in South Dakota

Beaver Creek is influenced by three tributaries which are located in Minnesota. They include Little Beaver Creek, Springwater Creek, and Fourmile Creek. The Central Big Sioux River Watershed Assessment Project has identified Beaver Creek for TMDL development due to not meeting the water quality criteria for suspended solids. Information supporting this listing was derived from monitoring data collected by the East Dakota Water Development District. Beaver Creek was not on any 303(d) State Waterbody lists prior to this assessment including 2006. Appendix B of the Assessment Report summarizes the data collected during the period of June 2000 to October 2001.

Problem Identification

Although Beaver Creek begins in Minnesota, the Central Big Sioux River Watershed Assessment evaluated only the portion within South Dakota. This portion begins at monitoring site T32, and then joins Split Rock Creek, which eventually runs into the Big Sioux River below the City of Brandon. The watershed area shown in Figure 2 drains approximately 98 percent grass/grazing land and cropland acres. The municipalities of Valley Springs in South Dakota and Beaver Creek in Minnesota may be influencing this tributary.

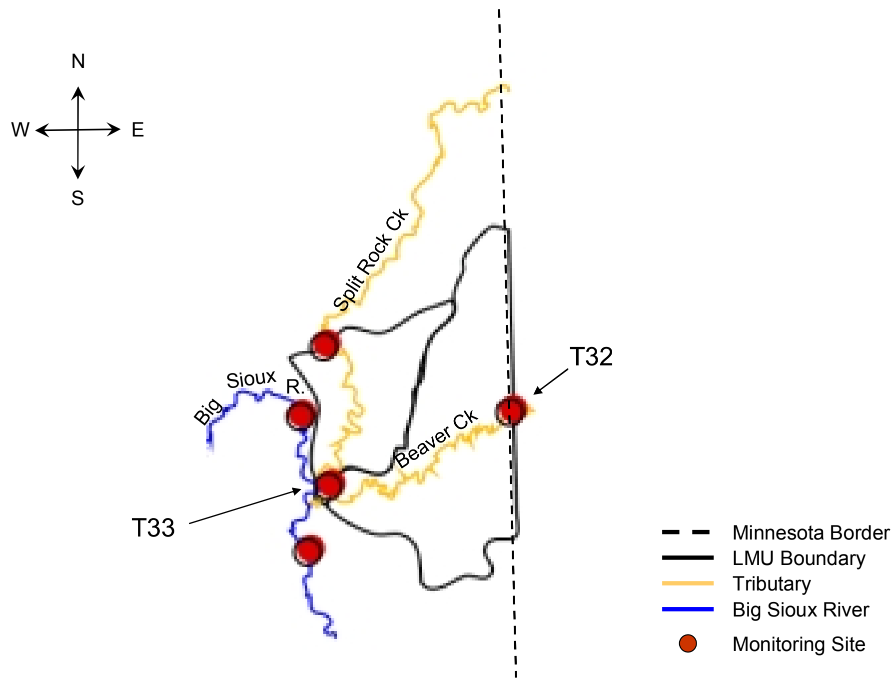


Figure 2. Beaver Creek Watershed

Beaver Creek was found to carry excessive sediment which degrades water quality. This tributary is considered impaired because more than 10 percent of the values (of more than 20 samples) exceeded the numeric criteria of ≤ 263 mg/L of total suspended solids per grab sample. A total of 34 water quality samples were taken from two monitoring locations (T32 and T33). Of these 34 samples, 29 percent were violating the water quality standards (Table 1). This 29 percent indicates that this tributary is not meeting the water quality criteria for beneficial use (6) Warmwater Marginal Fish Life Propagation. The excess sediment is believed to be coming from cropland runoff, streambank erosion, and construction erosion.

Table 1. Summary of Total Suspended Solids Data for Beaver Creek

Parameter Causing Impairment	Number of Samples	Percent of Samples > 263 mg/L	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
TSS	34	29	3	1,580

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Beaver Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this tributary. These criteria must be maintained for the segment to satisfy the assigned beneficial uses listed below:

- Warmwater marginal fish propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. This tributary experiences in-stream total suspended solid loading from bed/bank erosion and also external total suspended solid loading from its watershed. Beaver Creek is identified as not supporting its warmwater marginal fish life propagation beneficial use. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state.

To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. Beaver Creek is currently assigned a numeric standard of ≤ 263 mg/L for TSS. Assessment monitoring indicates that there is a 79 percent exceedence in TSS during high flow conditions. Excessive TSS can decrease water clarity and increase water temperatures. Due to its adsorbing quality, sediment can also carry nutrients, such as phosphorus. This excess in sediment can have adverse affects on fish and other aquatic life. Theoretically, sediment accumulates as it moves downstream. Therefore, the loading at the most downstream monitoring site (T33) determined the reductions required for this creek.

The tributaries of Little Beaver Creek, Springwater Creek, and Fourmile Creek join Beaver Creek within Minnesota. Although 60% of this watershed resides in Minnesota, this TMDL will focus only on the sediment loading of the South Dakota portion of this creek.

A flow duration interval with hydrologic zones approach was used to assess this tributary. This methodology, developed by Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences came during higher flow periods, then non-point sources of pollution should be suspected. Using Cleland's approach, the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods section of the Assessment Report.

The most downstream monitoring location (T33) was used to assess this stream using the flow duration interval method. Of the 17 water samples collected at this location, five (or 29 percent) violated the water quality standards for total suspended solids. Based on the water quality violations, Beaver Creek does not currently support its assigned beneficial use of Warmwater Marginal Fish Life Propagation. This creek requires reducing the pounds of total suspended solids per day, during high flows .

Beaver Creek flows into Split Rock Creek, which is assigned a more stringent numeric standard of ≤ 158 mg/L for TSS. Currently, a TMDL for Split Rock Creek is being developed. Therefore, Beaver Creek was also analyzed at the ≤ 158 mg/L standard. When the more stringent standard is applied larger reductions in the sediment load would be required during high flows. Improvements to sediment load in Beaver Creek are necessary to meet this TMDL and the goals of the Split Rock Creek TMDL.

According to Rule **74:51:01:04 Application of criterion to contiguous water states**,

> *"If pollutants are discharged into a segment and the criteria for that segments designated beneficial use are not exceeded but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, that pollutants may not cause the more stringent criteria to be exceeded."*

If one body of water runs into another body of water with a more stringent standard, the more stringent standard would apply to all waters of concern. In this case, if improvements at the ≤ 263 mg/L standard for Beaver Creek are sufficient in meeting this TMDL and the TMDL for Split Rock Creek, then no further action is required. However, if this TMDL does not satisfy the requirements of the Split Rock Creek TMDL, further evaluation of Beaver Creek at the ≤ 158 mg/L numeric standard will be necessary.

Pollutant Assessment

Point Sources

The City of Valley Springs is the only NPDES permitted facility associated with this watershed in South Dakota (Table 2). Total contribution from this facility during the study period is insignificant, at less than 0.000001 percent. Calculations used total kg for all facilities divided by the total kg from Site T33. The numbers shown in Table 2 are the potential load that could be delivered to Beaver Creek.

Table 2. NPDES Facilities.

Facility Name	Permit Number	TSS lbs/day
Valley Springs (WWTP)	SD0020923	397.7

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of total suspended solids include loadings from surface runoff, bed and bank erosion, cropland erosion, and construction erosion. Figure 3 depicts the flow of water in the watershed and shows the estimated reductions needed for each stream.

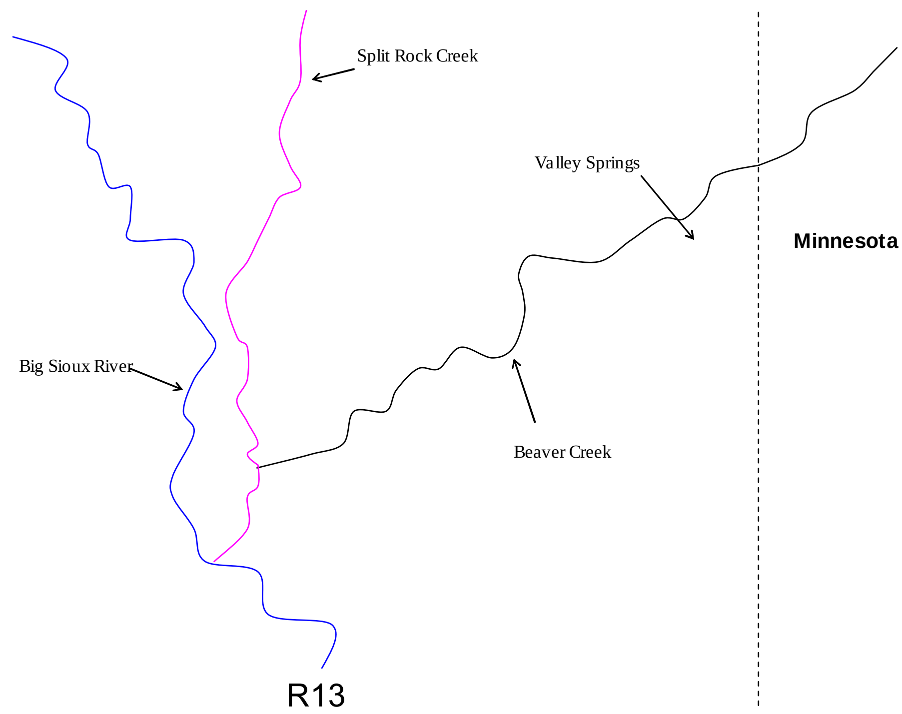


Figure 3. Water Flow in Beaver Creek Watershed

Linkage Analysis

Water quality data was collected at two monitoring sites on Beaver Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10 percent of the samples according to South Dakota's EPA approved Non-Point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Sediment Delivery Model (SDM) was used to define critical non-point source (NPS) pollution cells within the watershed (those with high sediment) and estimate the effective percent reduction needed in the watershed by adding various Best Management Practices (BMPs). See the Modeling and Results section of the final report for a complete summary of the results. The SDM was used to predict sediment loadings during 2, 5, 10, and 20 year (24 hour) rainfall events (Appendix Y, Assessment Report). Then best management practices, such as stream buffers and tillage practices, were applied to find achievable percent reductions (Appendix Z, Assessment Report).

The Flow Duration Interval Zone method calculates total suspended solids loading, (concentration) × (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of sediment for Beaver Creek, the range of flows from the monitoring location were divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows as ranges. The typical flow zones are High (0-10), Moist (10-40), Mid-range (40-

60), Dry (60-90), and Low (90-100). Excessive sediment loadings are occurring during the high flow conditions. Flow duration intervals were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 4, any samples occurring above this line is an exceedence of the currently assigned water quality standard and represented by a red box. Attachment 1 contains detailed exceedence information as well as a graph and data at the ≤ 158 mg/L numeric standard. Table 3 depicts the allowable sediment load during the study for peak flow, low flow, and 5th percentile increments in flow.

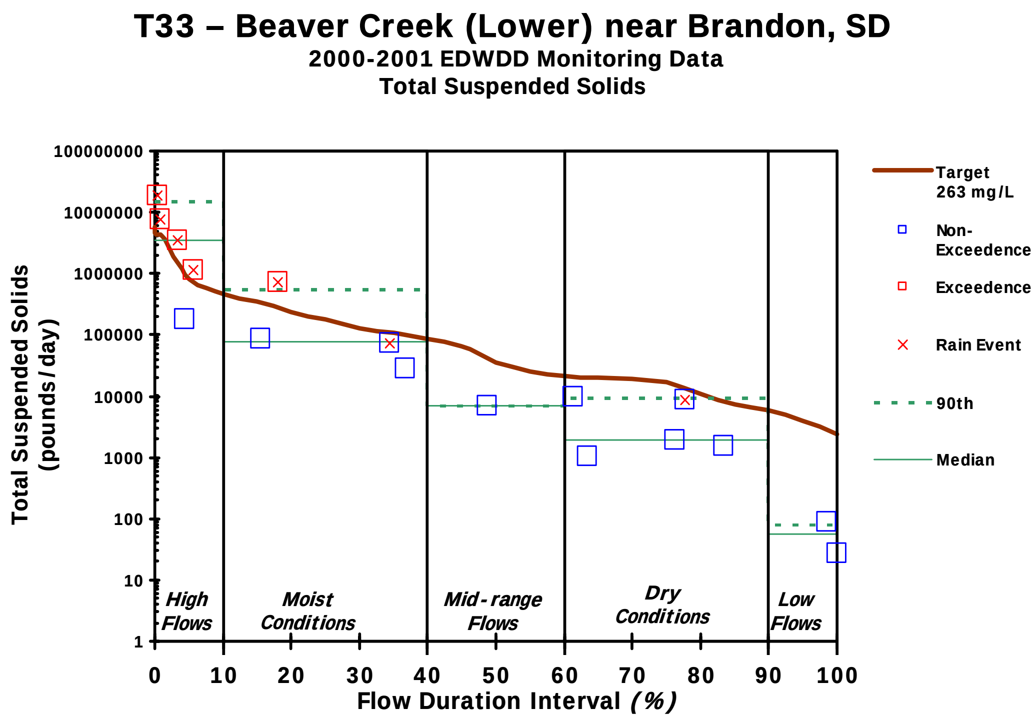


Figure 4. Flow Duration Interval for the Beaver Creek Watershed

Table 3. Sediment Target Loads for Flow

		Allowable Loads mg/L	263
Flow Rank (percent)	cfs	TSS (pounds/day)	Flow Conditions
0.019	4059.00	5.76E+06	Peak
0.100	3210.87	4.56E+06	
0.274	2998.30	4.26E+06	
1	2889.36	4.10E+06	
5	572.79	8.13E+05	
10	321.50	4.56E+05	
15	241.35	3.43E+05	
20	166.30	2.36E+05	
25	123.86	1.76E+05	
30	91.87	1.30E+05	
35	75.02	1.06E+05	
40	61.03	8.66E+04	
45	44.86	6.37E+04	
50	25.52	3.62E+04	
55	17.85	2.53E+04	
60	15.07	2.14E+04	
65	14.26	2.02E+04	
70	13.12	1.86E+04	
75	12.32	1.75E+04	
80	7.88	1.12E+04	
85	5.05	7.17E+03	
90	4.17	5.92E+03	
95	2.80	3.98E+03	
100	1.68	2.39E+03	Low

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as pounds/day)				
			High	Moist	Mid-Range	Dry	Low
SD-BS-R-BEAVER_02		TMDL	8.13E+05	1.76E+05	3.62E+04	1.75E+04	3.98E+03
		10% MOS	8.13E+04	1.76E+04	3.62E+03	1.75E+03	3.98E+02
		Total Allocations	7.32E+05	1.58E+05	3.26E+04	1.57E+04	3.58E+03
		LA	7.31E+05	1.58E+05	3.22E+04	1.53E+04	3.18E+03
	Valley Springs (WWTP)	WLA	3.98E+02	3.98E+02	3.98E+02	3.98E+02	3.98E+02
		Background	1.46E+04	3.16E+03	6.44E+02	3.07E+02	6.36E+01
		Other NPS	7.17E+05	1.55E+05	3.16E+04	1.50E+04	3.12E+03

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the suspended sediment standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 3.98×10^2 pounds if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet sediment standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the total suspended solids loading. Therefore, the "wasteload allocation" component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute sediment at rates above natural background. This includes cropland, pastureland, bed/bank erosion, and residential areas.

Predictions of sediment reduction were calculated using the Sediment Delivery Model (SDM). This model shows reductions based on land management units (See Figure 39 in the Assessment Report). Table 4 shows sediment loads during a two year rain event and the achievable reductions using buffers and conservation tillage. Figure 5 shows the locations of the targeted LMUs within the watershed.

Table 4. Sediment Loading by LMU for a Two Year Rain Event and Achievable Reductions

LMU	TSS Yield 2 Year Rain Event (tons)	% Decrease with Stream Buffer	% Decrease With No Tillage	Decrease with Combination Buffer & No Tillage
33	24081	8%	70%	72%
GG	7209	3%	69%	70%

Any remaining excess sediment is likely from bed and bank erosion. In which case, stream bank stabilization has shown to improve sediment reduction by 75 to 100 percent.

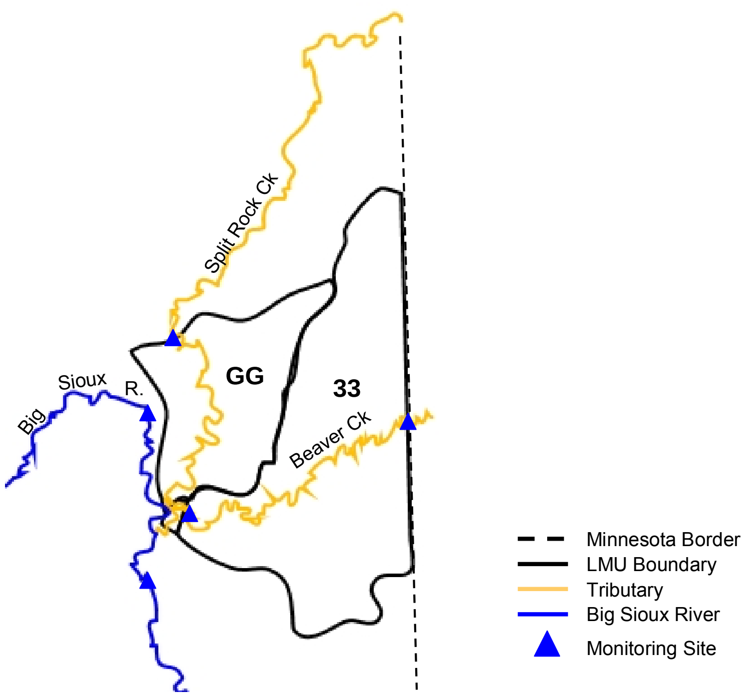


Figure 5. LMUs of the Beaver Creek Watershed

It should be noted that approximately 60 percent of Beaver Creek's watershed lies within Minnesota. It may be of benefit to work with the state of Minnesota on rectifying the sediment problems. Monitoring site T32 is located on the border between South Dakota and Minnesota. Water quality sampling at this site indicated a 29 percent violation rate as the waters entered the State of South Dakota.

It should also be noted that Beaver Creek joins Split Rock Creek below the City of Brandon in South Dakota. Split Rock Creek is currently assigned a numeric standard of ≤ 158 mg/L for TSS. This is a more stringent standard for TSS than what is currently assigned to Beaver Creek. However, a TMDL has been initiated for Split Rock Creek which addresses these sediment loading issues. It is possible that this TMDL may need to be revisited if it does not satisfy the requirements of the Split Rock Creek TMDL.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Beaver Creek is not meeting the water quality criteria for TSS. Of the samples taken that were exceeding the standard, 100 percent were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10 percent, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

Violations of the ≤ 263 mg/L standard for TSS occurred throughout the months of April-July in the Beaver Creek tributary. This is the result of seasonal precipitation which causes additional particles to be carried into the river.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameters of total solids and total suspended solids. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Beaver Creek TMDL

Implementation Plan

The East Dakota Water Development District is working with the City of Sioux Falls and various stakeholders to initiate an implementation project, which is estimated to begin in 2005. It is expected that a local sponsor will request Section 319 funding for project assistance during early2005.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 263 mg/L) for total suspended solids. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the TSS concentrations by 79 percent under high flow conditions (Table 5). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 5. Beaver Creek Total Suspended Solids Reductions at the ≤ 263 mg/L Numeric Standard

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	6.15E+03	6.37E+02	2.72E+02	1.55E+02	2.00E+01
X	Flow Median (cfs)	572.79	123.86	25.52	12.32	2.80
=	Existing	3.52E+06	7.89E+04	6.93E+03	1.91E+03	5.60E+01
	Target Load (at 263 mg/L)	8.13E+05	1.76E+05	3.62E+04	1.75E+04	3.98E+03
	% Reduction w/MOS	79	0	0	0	0

Note: units are pounds/day

Beaver Creek flows into Split Rock Creek, which is assigned a more stringent numeric standard of ≤ 158 mg/L for TSS. Therefore, Beaver Creek was also analyzed at the ≤ 158 mg/L standard. When the more stringent standard is applied an 87 percent reduction in sediment load is required during high flows (Table 6). Improvements to sediment load in Beaver Creek are necessary to meet this TMDL and the goals of the Split Rock Creek TMDL.

Table 6. Beaver Creek Total Suspended Solids Reductions at the ≤ 158 mg/L Numeric Standard

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	6.15E+03	6.37E+02	2.72E+02	1.55E+02	2.00E+01
X	Flow Median (cfs)	572.79	123.86	25.52	12.32	2.80
=	Existing	3.52E+06	7.89E+04	6.93E+03	1.91E+03	5.60E+01
	Target Load (at 158 mg/L)	4.88E+05	1.06E+05	2.18E+04	1.05E+04	2.39E+03
	% Reduction w/MOS	87	0	0	0	0

Note: units are pounds/day

Beaver Creek Total Suspended Solids Exceedences

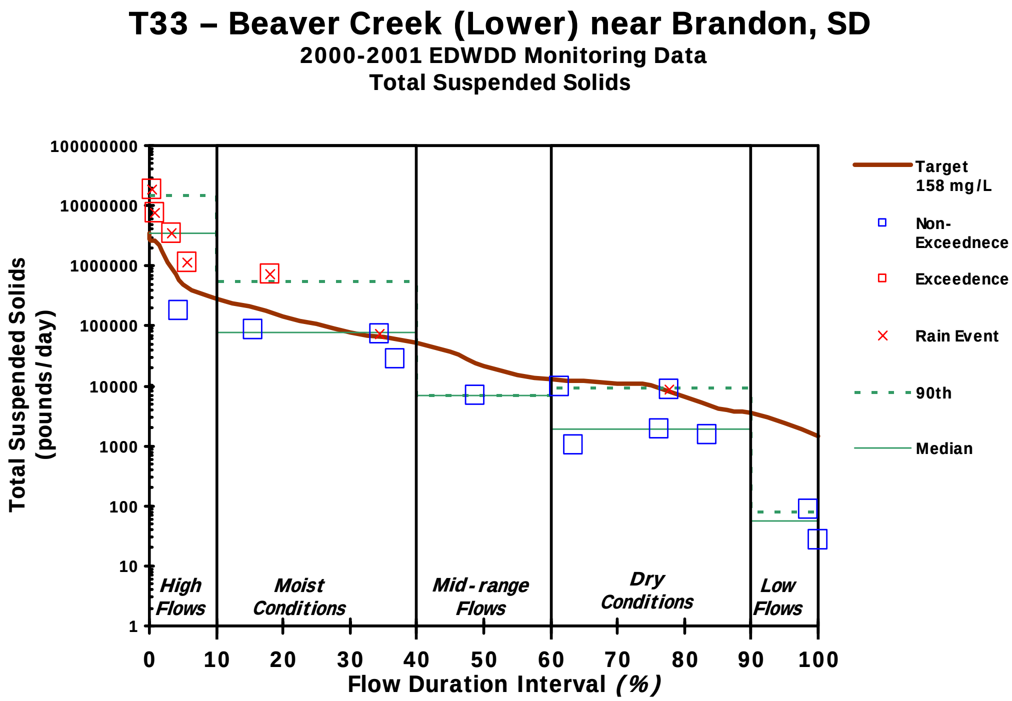
Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	TSS (mg/L)	TSS Load (pounds/day)
T33	06/13/01	1445	2679	0.0051	0.51	1312	1.90E+07
T33	04/12/01	1145	866	0.0345	3.45	754	3.52E+06
T33	04/02/01	1410	202	0.1797	17.97	678	7.39E+05
T33	04/24/01	1210	2212	0.0089	0.89	654	7.81E+06
T33	05/07/01	1400	567	0.0559	5.59	364	1.11E+06

Beaver Creek TSS Reductions at 158 mg/L

	Median	High Flows (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low Flows (90-100)
	Median Concentration (pounds/day)	6.15E+03	6.37E+02	2.72E+02	1.55E+02	2.00E+01
X	Flow Median (cfs)	572.79	123.86	25.52	12.32	2.80
=	Existing	3.52E+06	7.89E+04	6.93E+03	1.91E+03	5.60E+01
	Target Load (at 158 mg/L)	4.88E+05	1.06E+05	2.18E+04	1.05E+04	2.39E+03
	% Reduction w/MOS	87	0	0	0	0

Note: units are pounds/day

Flow Rank (percent)	cfs	Allowable Loads 158 mg/L TSS (pounds/day)	Flow Conditions
0.019	4059.00	3.46E+06	Peak
0.100	3210.87	2.74E+06	
0.274	2998.30	2.56E+06	
1	2889.36	2.46E+06	
5	572.79	4.88E+05	
10	321.50	2.74E+05	
15	241.35	2.06E+05	
20	166.30	1.42E+05	
25	123.86	1.06E+05	
30	91.87	7.83E+04	
35	75.02	6.40E+04	
40	61.03	5.20E+04	
45	44.86	3.82E+04	
50	25.52	2.18E+04	
55	17.85	1.52E+04	
60	15.07	1.29E+04	
65	14.26	1.22E+04	
70	13.12	1.12E+04	
75	12.32	1.05E+04	
80	7.88	6.72E+03	
85	5.05	4.31E+03	
90	4.17	3.56E+03	
95	2.80	2.39E+03	
100	1.68	1.44E+03	Low


T33 – Beaver Creek (Lower) near Brandon, SD
2000-2001 EDWDD Monitoring Data
Total Suspended Solids
Total Suspended Solids (pounds / day)
100000000
10000000
1000000
100000
10000
1000
100
10
1
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Duration Interval (%)
Target 158 mg/L
Non-Exceednece
Exceedence
Rain Event
90th
Median

Appendix DDD.
TMDL – Beaver Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Beaver Creek
(within South Dakota)

(HUC 10170203)

Minnehaha County, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Beaver Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-BEAVER_02
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Stream:	17.1 miles (within South Dakota)
Size of Watershed:	39,548 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Beaver Creek is a 17.1 mile portion of tributary with a watershed (LMUs 33 and GG) of approximately 39,548 acres (within South Dakota). Beaver Creek is a tributary to Split Rock Creek (HUC 10170203) in southeastern Minnehaha County in South Dakota. This watershed lies within Minnehaha County as shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

Beaver Creek is influenced by three tributaries, all of which are located in Minnesota. They include Little Beaver Creek, Springwater Creek, and Fourmile Creek. The Central Big Sioux River Watershed Assessment Project identified Beaver Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Beaver Creek was not on any 303(d) State Waterbody lists prior to this assessment including the 2006 list. Appendix B of the Assessment Report summarizes the data collected during the period of June 2000 to September 2001.

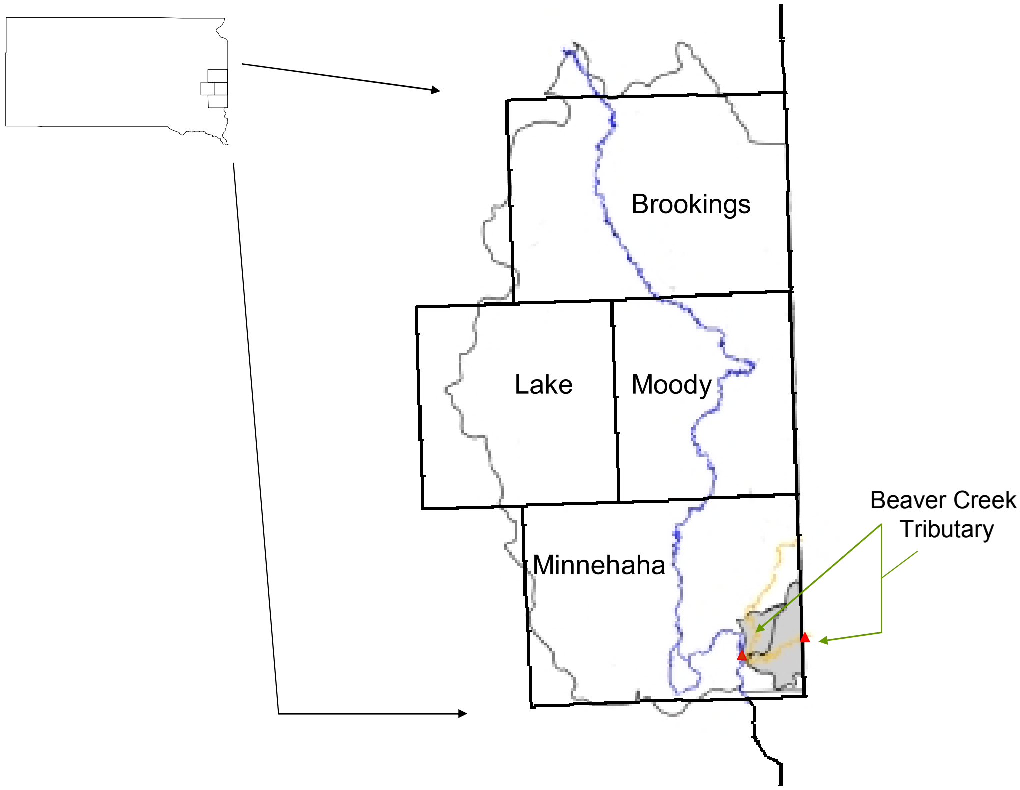


Figure 1. Location of Beaver Creek in South Dakota

Problem Identification

Although Beaver Creek begins in Minnesota, the Central Big Sioux River Watershed Assessment evaluated only the portion within South Dakota. This portion begins at monitoring site T32, and then joins Split Rock Creek, which eventually runs into the Big Sioux River below the City of Brandon. The watershed area shown in Figure 2 drains approximately 98 percent grass/grazing land and cropland acres. The municipalities of Valley Springs in South Dakota and Beaver Creek in Minnesota may be influencing this tributary.

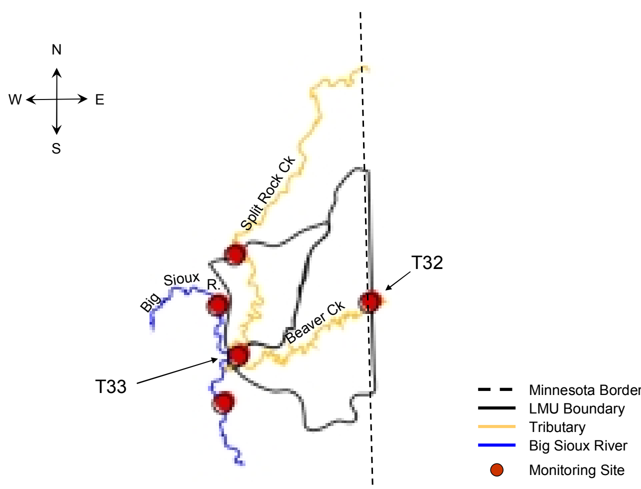


Figure 2. Beaver Creek Watershed

Beaver Creek was found to carry fecal coliform bacteria which degrades water quality. This tributary is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters of fecal colifom bacteria during the season of May 1 to September 30. Table 1 displays the fecal coliform data collected from May 2000 to September 2000 and from May 2001 to September 2001.

Table 1. Summary of Fecal Coliform Data for Beaver Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	22	41	120	172,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Beaver Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this river segment. These criteria must be maintained for the segment to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This segment experiences fecal coliform loading due to poor riparian areas, in-stream livestock, feedlots/manure runoff, and NPDES systems. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

The tributaries of Little Beaver Creek, Springwater Creek, and Fourmile Creek join Beaver Creek within Minnesota. Although 60% of this watershed resides in Minnesota, this TMDL will focus only on the fecal coliform bacteria loading of the South Dakota portion of this creek.

Beaver Creek is currently assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this segment. This methodology, developed by Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low-flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Clelands's approach the following four hydrologic conditions were utilized: High/Moist Conditions (0-40 percent), Mid-Range Flows (40-60 percent), and Dry/Low Flow Conditions (60-100 percent). The methodology of flow duration interval is explained further in the Methods Section of the Assessment Report.

Two monitoring locations were setup on Beaver Creek. Of the, 22 water samples that were collected, nine (or 41 percent) violated the water quality standards. Based on the water quality violations, this segment is currently not supporting its limited contact recreation beneficial use (Appendix FF, Assessment Report).

Beaver Creek flows into Split Rock Creek, which is assigned a more stringent numeric standard of ≤ 400 cfu/100mL for fecal coliform bacteria. Currently, a TMDL for Split Rock Creek is being developed. Therefore, Beaver Creek was also analyzed at the ≤ 400 cfu/100mL standard. At ≤ 400 cfu/100mL, this segment requires significantly higher reductions for fecal coliform counts per day during high/moist conditions, mid-range flows, and dry/low conditions..

Improvements to the fecal coliform load in Beaver Creek is necessary to meet this TMDL and the goals of the Split Rock Creek TMDL. According to Rule **74:51:01:04 Application of criterion to contiguous water states**,

> *"If pollutants are discharged into a segment and the criteria for that segments designated beneficial use are not exceeded but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, that pollutants may not cause the more stringent criteria to be exceeded."*

This basically means if one body of water runs into another body of water with a more stringent standard, the more stringent standard would apply to all waters of concern. In this case, if improvements at the ≤ 2,000 cfu/100 mL standards for Beaver Creek are sufficient in meeting this TMDL and the TMDL for Split Rock Creek, then no further action is required. However, if this TMDL does not satisfy the requirements of the Split Rock Creek TMDL, further evaluation of Beaver Creek at the ≤ 400 cfu/100mL numeric standard will be necessary.

Pollutant Assessment

Point Sources

The only NPDES facility taken into consideration within this area is the City of Valley Springs (Table 2). There was a zero percent contribution, as this facility did not discharge during the study period. The worst case scenario of the City of Valley Springs within this segment would be approximately 4.01×10^{10} fecal counts if the WWTF discharged their maximum amount possible. The numbers shown in Table 2 are the potential load that could be delivered to Skunk Creek.

Table 2. NPDES Facilities.

Facility Name	Permit Number	# colonies/day
Valley Springs (WWTP)	SD0020923	4.01E+10

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 3.

Table 3. Livestock in the Beaver Creek Watershed

Livestock Distribution	Beaver Creek
Beef Cattle/Calves	1931
Hogs/Pigs	1000
Dairy Cattle	230

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 4 shows that 99 percent of the area is grass or cropland. Urban areas would fall into the artificial category, which makes up approximately one percent of the watershed.

Table 4. Landuse in the Beaver Creek Watershed

LandUse	Percent	Acres
Water	0%	27
Trees	1%	177
Artificial	1%	190
Barren	0%	27
Grass	28%	7,644
LEP Cropland	40%	10,786
MEP Cropland	17%	4,605
HEP Cropland	14%	3,729

LEP = Low Erosion Potential

MEP = Medium Erosion Potential

HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at two monitoring sites (T32 and T33) on Beaver Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) x (flow), using zones based on hydrologic conditions. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this tributary, the range of flows from each of the two monitoring locations were merged to form the duration interval curve and were then divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this creek, the ranges or flow zones are High/Moist (0-40), Mid-Range (40-60), and Dry/Low (60-100). Load duration curves were calculated using the following equation:

$$(\text{flow}) \times (\text{conversion factor}) \times (\text{state criteria}) = \text{quantity/day or daily load}$$

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard (≤ 2,000 cfu/100mL) and represented by a red box (See Attachment 2 for details). Table 5 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow.

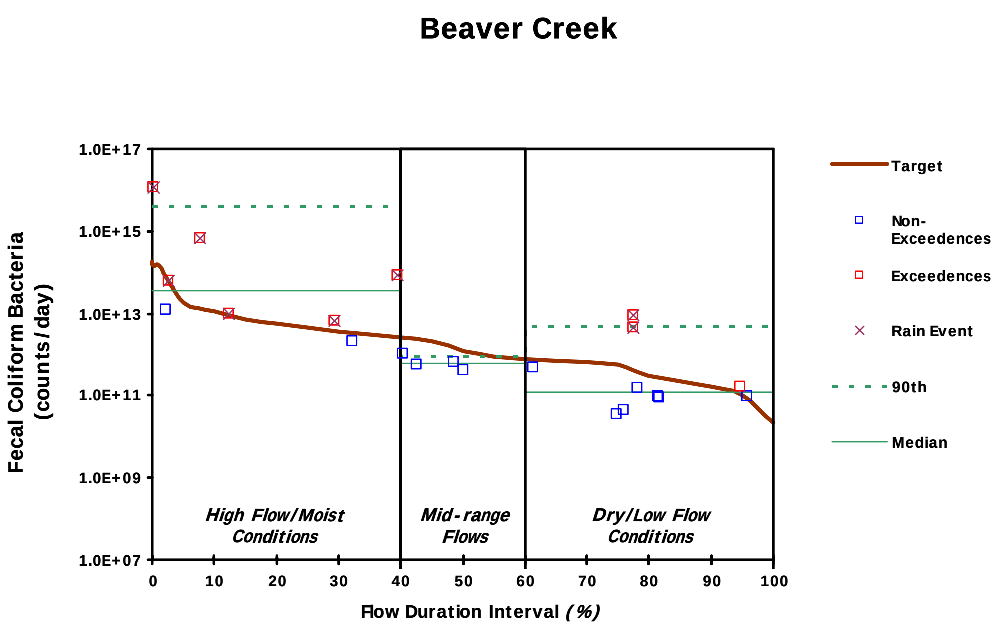


Figure 3. Flow Duration Interval for Beaver Creek at ≤ 2,000 cfu/100mL

Table 5. Fecal Coliform Target Loads for Flow

		Allowable Loads 400 cfu/100mL	
(percent)	cfs	Coliform	Conditions
0.019	3621.34	1.77E+14	Peak
0.100	3114.83	1.52E+14	
0.274	2971.92	1.45E+14	
1	2889.36	1.41E+14	
5	354.36	1.73E+13	
10	225.47	1.10E+13	
15	146.22	7.16E+12	
20	115.50	5.65E+12	
25	90.37	4.42E+12	
30	75.05	3.67E+12	
35	60.96	2.98E+12	
40	52.69	2.58E+12	
45	41.55	2.03E+12	
50	25.31	1.24E+12	
55	17.73	8.68E+11	
60	15.07	7.38E+11	
65	14.26	6.98E+11	
70	13.14	6.43E+11	
75	11.71	5.73E+11	
80	6.05	2.96E+11	
85	4.53	2.22E+11	
90	3.31	1.62E+11	
95	2.08	1.02E+11	
100	0.44	2.15E+10	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 6 lists the five feedlots that rated 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying those regions of concern is shown in Figure 4. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 6. Feedlot ratings above 50 for the Beaver Creek Watershed

LMU	Feedlot Rating
33	64
33	55
33	58
33	51
33	50

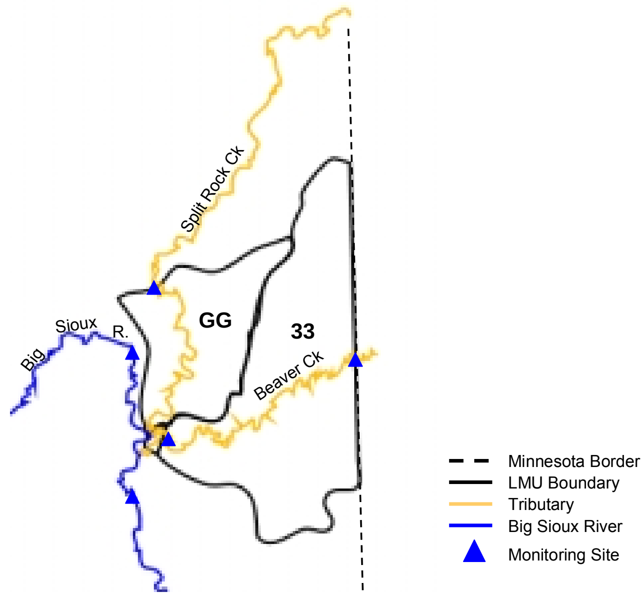


Figure 4. LMU Map of the Beaver Creek Watershed

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)		
			High/Moist	Mid-Range	Dry/Low
SD-BS-R-BEAVER_02		TMDL	5.65E+12	1.24E+12	2.96E+11
		10% MOS	5.65E+11	1.24E+11	2.96E+10
		Total Allocations	5.09E+12	1.12E+12	2.66E+11
		LA	5.04E+12	1.08E+12	2.26E+11
	Valley Springs (WWTP)	WLA	4.01E+10	4.01E+10	4.01E+10
		Background	1.01E+11	2.15E+10	4.53E+09
		Other NPS	4.94E+12	1.05E+12	2.22E+11

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 4.01×10^{10} fecal counts if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this stream will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. The identified point source in this watershed is contributing an insignificant amount to the fecal coliform loading. Therefore, the "wasteload allocation" component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, reductions are needed from non-point sources during high flows/moist conditions (refer to Figure 3), as shown in Table 2.

It should be noted that approximately 80 percent of Beaver Creek's watershed lies within Minnesota. It may be of benefit to work with the state of Minnesota on rectifying the fecal coliform bacteria problems. Monitoring site T32 is located on the border between South Dakota and Minnesota. At this location, water quality monitoring indicates there is already a 36 percent exceedence as the waters enter the State of South Dakota.

It should also be noted that Beaver Creek joins Split Rock Creek below the City of Brandon in South Dakota. Split Rock Creek is currently assigned a numeric standard of ≤ 400 cfu/100mL for fecal coliform bacteria. This is a more stringent standard for fecal coliform bacteria than what is currently assigned to Beaver Creek. However, a TMDL has been initiated for Split Rock Creek which addresses these fecal coliform loading issues. It is possible that this TMDL may need to be revisited if it does not satisfy the requirements of the Split Rock Creek TMDL.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Both monitoring sites (T32 and T33) are not meeting the water quality criteria for fecal coliform bacteria. Of the samples taken that were exceeding the standard (≤ 2,000 cfu/100mL), 89 percent were during rain events (See Appendix B of the Assessment Report for EDWDD samples). An evaluation at ≤ 400 cfu/100mL showed 40 percent were during rain events.

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Beaver Creek TMDL

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this tributary. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop and implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 86 percent during high to moist flow conditions (Table 7). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 7. Beaver Creek Fecal Coliform Reductions (2,000 cfu/100mL)

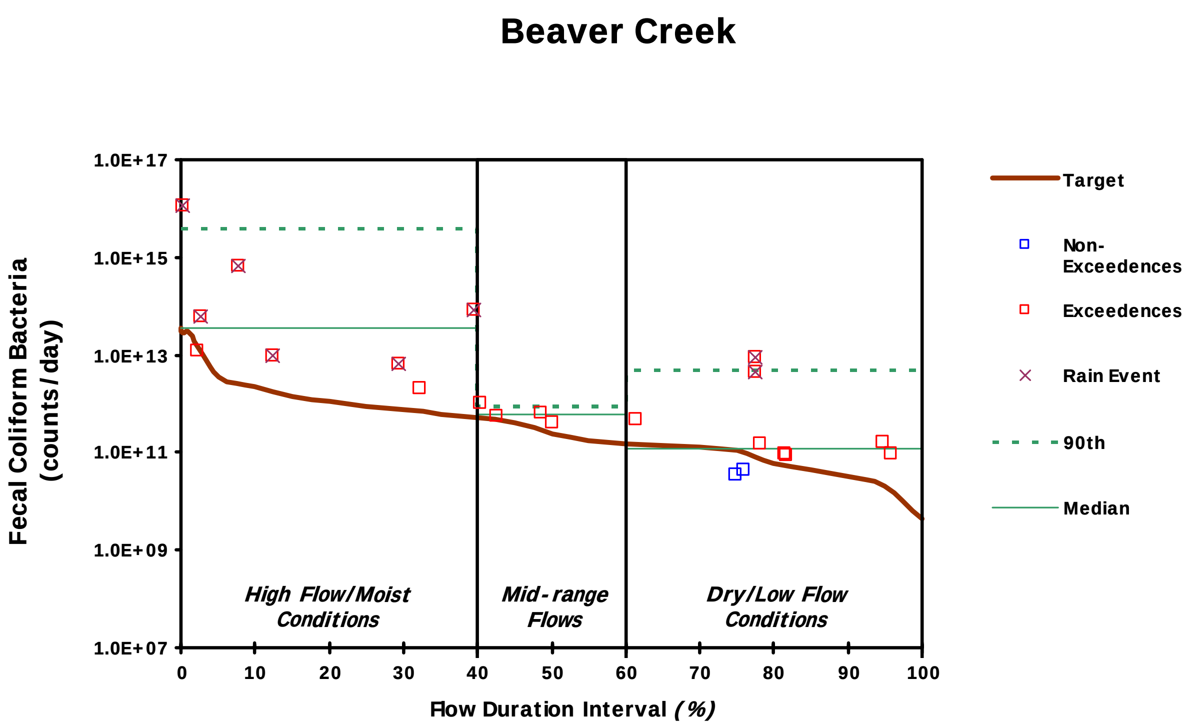
	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry/Low (60-100)
	Median Concentration (counts/day)	3.19E+11	2.41E+10	2.05E+10
X	Flow Median (cfs)	115.5	25.31	6.05
=	Existing	3.68E+13	6.10E+11	1.24E+11
	Target Load (at 2,000 cfu/100mL)	5.65E+12	1.24E+12	2.96E+11
	% Reduction w/MOS	86	0	0

Note: units are counts/day

Fecal Reductions at 400 cfu/100mL for Beaver Creek

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry/Low (60-100)
	Median Concentration (counts/day)	3.19E+11	2.41E+10	2.05E+10
X	Flow Median (cfs)	115.5	25.31	6.05
=	Existing	3.68E+13	6.10E+11	1.24E+11
	Target Load (at 400 cfu/100mL)	1.13E+12	2.48E+11	5.92E+10
	% Reduction w/MOS	97	63	57

Note: units are counts/day



Fecal Exceedences for Beaver Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Coliform Load (counts/day)
T33	06/13/01	1445	2678.52	0.0025	0.25	172000	1.12735E+16
T32	06/13/01	1400	278.33	0.0767	7.67	96000	6.53839E+14
T32	07/23/01	1300	53.77	0.3962	39.62	65000	8.55292E+13
T33	07/10/00	1450	9.68	0.7748	77.48	37000	8.77E+12
T32	07/10/00	1430	9.22	0.7756	77.56	20000	4.51E+12
T33	05/07/01	1400	566.66	0.0275	2.75	4400	6.10E+13
T33	07/23/01	1315	76.40	0.2947	29.47	3400	6.36E+12
T33	09/19/00	1500	2.28	0.9475	94.75	2900	1.61E+11
T32	05/07/01	1330	190.38	0.1235	12.35	2100	9.78E+12

Appendix EEE.
TMDL – Pipestone Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Pipestone Creek
(within South Dakota)

(HUC 10170203)

Moody and Minnehaha Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Pipestone Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-PIPESTONE_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Semipermanent Fish Life Propagation Immersion Recreation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Stream:	35.4 miles (within South Dakota)
Size of Watershed:	45,993 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Immersion Recreation Beneficial Use during the months of May through September
Target:	≤ 400 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective
The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction
Pipestone Creek is a 35.4 mile portion of tributary with a watershed of approximately 45,993 acres (within South Dakota), and includes LMUs 28, 29, and Z. Pipestone Creek begins in Pipestone County, Minnesota, then wraps through Moody and Minnehaha Counties in South Dakota, and finally joins Split Rock Creek in Rock County, Minnesota. The watershed in South Dakota lies within Moody and Minnehaha Counties as shown by the shaded region in Figure 1 and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1.

Pipestone Creek is influenced by two tributaries, South Branch Pipestone Creek and North Branch Pipestone Creek, which are located in Minnesota. The Central Big Sioux River Watershed Assessment Project identified Pipestone Creek (within South Dakota) for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Pipestone Creek was not on any 303(d) State Waterbody lists prior to this assessment including 2006. Appendix B of the Assessment Report summarizes the data collected during the period of June 2000 to September 2001.

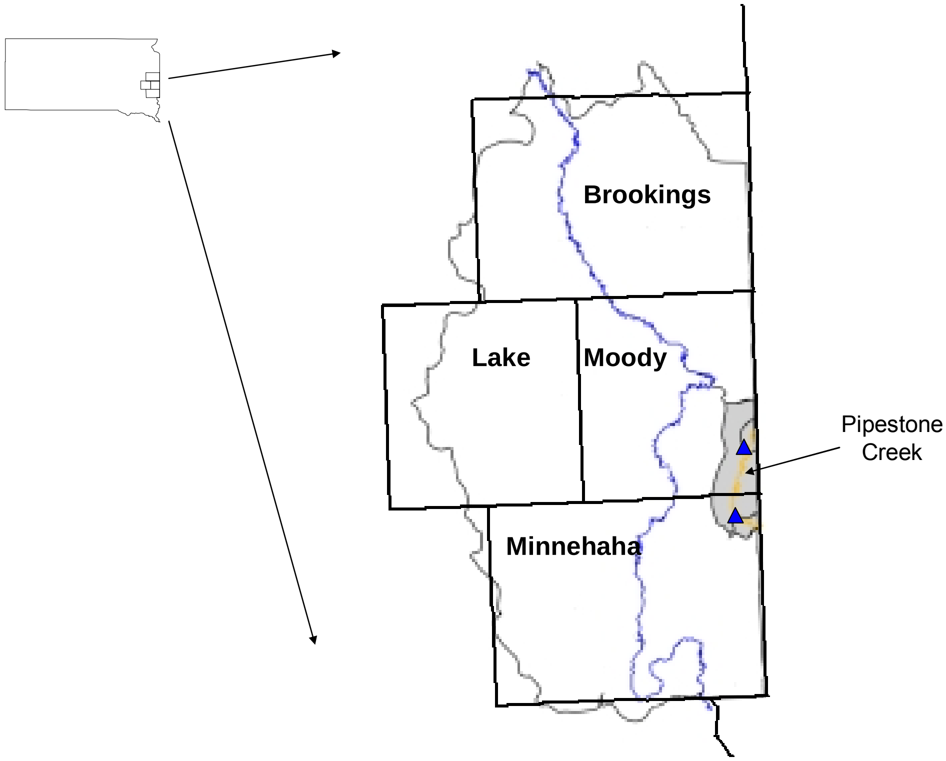


Figure 1. Location of Pipestone Creek in South Dakota

Problem Identification

Although Pipestone Creek begins and ends in Minnesota, the Central Big Sioux River Watershed Assessment evaluated only the portion within South Dakota. This portion begins at monitoring site T28 and ends at monitoring site T29. Pipestone Creek joins Split Rock Creek in Minnesota, which eventually runs into the Big Sioux River below the City of Brandon. The watershed area shown in Figure 2 drains approximately 99 percent grass/grazing land and cropland acres. The municipality of Pipestone in Minnesota, may be influencing this tributary.

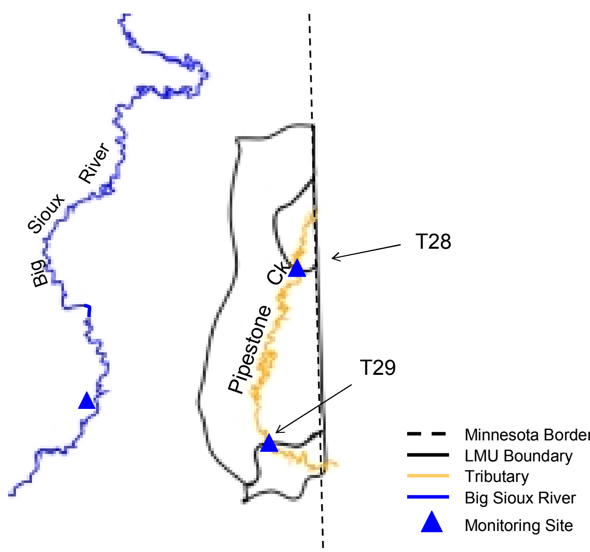


Figure 2. Pipestone Creek Watershed

Pipestone Creek was found to carry fecal coliform bacteria which degrades water quality. This tributary is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 400 counts per 100 milliliters of fecal colifom bacteria during the season of May 1 to September 30. Table 1 displays the fecal coliform data collected from June 2000 to September 2000 and from May 2001 to September 2001.

Table 1. Summary of Fecal Coliform Data for Pipestone Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 400 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	22	86.4	310	25,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Pipestone Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this tributary. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater semipermanent fish life propagation
- Immersion recreation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. Individual parameters determine the support of beneficial uses. Use support for immersion recreation and limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria. This stream experiences excessive fecal coliform loading due to poor riparian areas, in-stream livestock, feedlots/manure runoff, and pastured livestock.

Pipestone Creek was evaluated using the more stringent numeric standard of ≤ 400 cfu/100mL. Results show that this stream is not supporting for its immersion recreation beneficial use. Further analysis shows that this stream is not supporting of its limited contact recreation beneficial use even when the ≤ 2,000 cfu/100mL numeric standard is applied. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Bruce Cleland (Cleland 2003), was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions. For example, if all of the exceedences occurred during low flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Clelands's approach the following three hydrologic conditions were utilized: High/Moist Conditions (0-40 percent), Mid-Range Flows (40-60 percent), and Dry/Low Flow Conditions (60-100 percent). The methodology of flow duration intervals is explained further in the Methods Section of the Assessment Report.

Two monitoring locations, T28 and T29, were setup on Pipestone Creek. Of the 22 water samples that were collected, 19 (or 86.4 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, this stream is currently not supporting its immersion recreation or its limited contact recreation beneficial uses (Appendix FF, Assessment Report).

Pipestone Creek flows into Split Rock Creek, which is also assigned a numeric standard of ≤ 400 cfu/100mL for fecal coliform bacteria. Currently, a TMDL for Split Rock Creek is being developed. Therefore, improvements to the fecal coliform load in Pipestone Creek are necessary to meet this TMDL and the goals of the Split Rock Creek TMDL.

Pollutant Assessment

Point Sources

There are no identified NPDES facilities within the South Dakota portion of the watershed.

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 2.

Table 2. Livestock in the Pipestone Creek Watershed in South Dakota

Livestock Distribution	Pipestone Ck
Beef Cattle/Calves	4570
Hogs/Pigs	400
Dairy Cattle	150
Sheep	100

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. Fecal coliform from failing septic systems may be absorbed in the soil and vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 3 shows that 99 percent of the area is grass or cropland.

Table 3. Landuse in the Pipestone Creek Watershed

Landuse	Percent	Acres
Water	0%	28
Trees	0%	124
Artificial	1%	244
Barren	0%	32
Grass	17%	7,713
LEP Cropland	81%	37,295
MEP Cropland	1%	478
HEP Cropland	0%	78

LEP = Low Erosion Potential
MEP= Medium Erosion Potential
HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at two monitoring sites (T28 and T29) on Pipestone Creek. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings, South Dakota and by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) x (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for this tributary, the range of flows from each of the two monitoring locations were merged to form the flow duration interval curve and were then divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this stream, the ranges or flow zones are High Flow/Moist Conditions (0-40), Mid-Range Flows (40-60), and Dry/Low Flow Conditions (60-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 3, any samples occurring above this line is an exceedence of the water quality standard (≤ 400 cfu/100mL) and

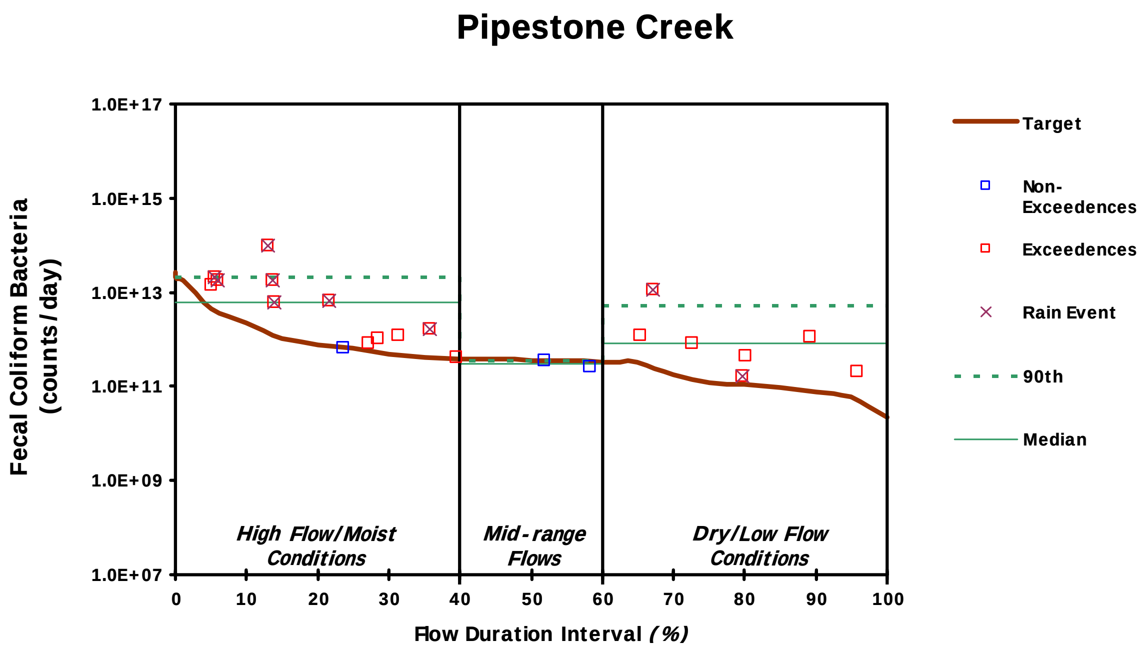


Figure 3. Flow Duration Interval for Pipestone Creek at ≤ 400 cfu/100mL

represented by a red box.. Table 3 depicts the allowable coliform bacteria load for peak flow, low flow, and 5th percentile increments in flow.

Table 3. Fecal Coliform Target Loads for Flow

		Allowable Loads 400 cfu/100mL	
Flow Rank (percent)	**cfs**	**Fecal Coliform (counts/day)**	**Flow Conditions**
0.019	2596.19	2.54E+13	Peak
0.100	2107.78	2.06E+13	
0.274	1937.67	1.90E+13	
1	1878.66	1.84E+13	
5	468.39	4.58E+12	
10	229.12	2.24E+12	
15	109.27	1.07E+12	
20	75.20	7.36E+11	
25	64.81	6.34E+11	
30	50.94	4.99E+11	
35	43.40	4.25E+11	
40	39.46	3.86E+11	
45	38.06	3.73E+11	
50	36.92	3.61E+11	
55	35.82	3.51E+11	
60	34.20	3.35E+11	
65	33.46	3.27E+11	
70	17.47	1.71E+11	
75	12.61	1.23E+11	
80	11.29	1.10E+11	
85	9.53	9.33E+10	
90	7.58	7.42E+10	
95	6.12	5.99E+10	
100	2.18	2.13E+10	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. Table 4 lists the ten feedlots that rated 50 or greater, which would warrant concern in regards to potential pollution problems. A map identifying those regions of concern is shown in Figure 4. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 4. Feedlot ratings ≥ 50 for the Pipestone Creek Watershed

LMU	Feedlot Rating
28	56
28	54
29	54
29	56
29	55
29	66
29	59
29	74
29	53
Z	50

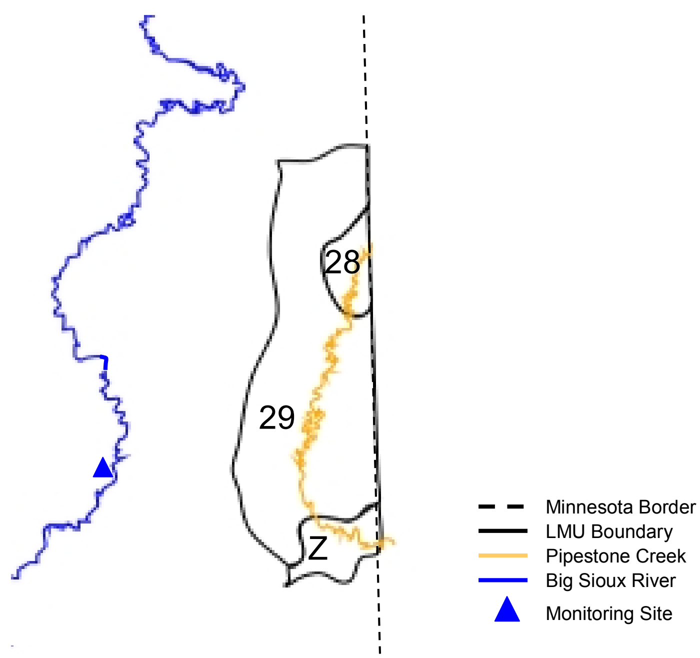


Figure 4. LMUs of the Pipestone Creek Watershed in South Dakota

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)		
			High/Moist	Mid-Range	Dry/Low
SD-BS-R-PIPESTONE_01		TMDL	7.36E+11	3.61E+11	1.10E+11
		10% MOS	7.36E+10	3.61E+10	1.10E+10
		Total Allocations	6.62E+11	3.25E+11	9.90E+10
		LA	6.62E+11	3.25E+11	9.90E+10
		WLA	-	-	-
		Background	1.32E+10	6.50E+09	1.98E+09
		Other NPS	6.49E+11	3.18E+11	9.70E+10

Wasteload Allocations (WLAs)

There are no identified point sources in this watershed. Therefore, the "wasteload allocation" component of this TMDL is zero.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Since there are no WLAs within this watershed, load allocations from non-point sources account for the total target load. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Reductions are needed from non-point sources during high flows/moist conditions and dry/low flow conditions (refer to Figure 3).

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Both monitoring sites (T28 and T29) are not meeting the water quality criteria for fecal coliform bacteria. Of the samples collected that were exceeding the standard (≤ 400 cfu/100mL), 53 percent were during rain events (See Appendix B of the Assessment Report for EDWDD samples).

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Pipestone Creek TMDL

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this tributary. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies, as well as agencies in Minnesota, will be needed in order to develop an implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 400 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 89 percent during high to moist flow conditions and 87% during dry/low flow conditions(Table 5). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 5. Pipestone Creek Fecal Coliform Reductions

	Median	High/Moist (0-40)	Mid-Range (40-60)	Dry (60-90)
	Median Concentration (counts/day)	8.05E+10	8.42E+09	7.06E+10
X	Flow Median (cfs)	75.20	36.92	11.29
=	Existing	6.05E+12	3.11E+11	7.97E+11
	Target Load (at 400 cfu/100mL)	7.36E+11	3.61E+11	1.10E+11
	% Reduction w/MOS	89	0	87

Note: units are counts/day

Fecal Exceedences for Pipestone Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T28	06/13/01	900	161.16	0.1298	12.98	25000	9.86E+13
T28	07/23/01	930	26.68	0.6712	67.12	17000	1.11E+13
T28	08/15/00	1545	7.71	0.8924	89.24	6000	1.13E+12
T29	06/13/01	1000	142.00	0.1364	13.64	5000	1.74E+13
T29	07/23/01	1030	69.64	0.2154	21.54	4000	6.82E+12
T28	08/14/01	930	13.57	0.7262	72.62	2400	7.97E+11
T29	05/07/01	1015	446.27	0.0542	5.42	1900	2.07E+13
T28	06/13/00	1315	137.44	0.1392	13.92	1800	6.05E+12
T28	05/07/01	940	412.91	0.0603	6.03	1800	1.82E+13
T28	09/11/01	930	11.13	0.8015	80.15	1600	4.36E+11
T29	07/10/00	1030	41.95	0.3582	35.82	1600	1.64E+12
T29	09/19/00	1030	33.42	0.6526	65.26	1500	1.23E+12
T28	09/19/00	1000	6.05	0.958	95.8	1400	2.07E+11
T29	06/13/00	1345	465.65	0.0518	5.18	1300	1.48E+13
T28	06/05/01	945	48.15	0.3145	31.45	1000	1.18E+12
T28	07/09/01	1000	54.10	0.2841	28.41	800	1.06E+12
T28	07/10/00	950	11.38	0.7978	79.78	580	1.62E+11
T29	07/09/01	1030	59.16	0.2709	27.09	560	8.11E+11
T29	08/14/01	1000	39.66	0.396	39.6	420	4.08E+11

Appendix FFF.
TMDL – Skunk Creek
(Fecal Coliform Bacteria)

TOTAL MAXIMUM DAILY LOAD EVALUATION
(Fecal Coliform Bacteria)

for

Skunk Creek

(HUC 10170203)

Lake, Moody and Minnehaha Counties, South Dakota

East Dakota Water Development District
Brookings, South Dakota

December 2004

Skunk Creek Total Maximum Daily Load

Waterbody Type:	Stream
Assessment Unit ID:	SD-BS-R-SKUNK_01
303(d) Listing Parameter:	Fecal Coliform Bacteria
Designated Uses:	Warmwater Marginal Fish Life Propagation Limited Contact Recreation Fish and Wildlife Propagation Recreation and Stock Watering Irrigation
Length of Stream:	74.3 miles
Size of Watershed:	372,571 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Water Chemistry
Analytical Approach:	Modeling and Assessment Techniques used include Flow Duration Interval Zones and AGNPS Model
Location:	HUC Code: 10170203
Goal:	Full Support of the Limited Contact Recreation Beneficial Use during the months of May through September
Target:	≤ 2,000 cfu/100mL of fecal coliform bacteria (any one sample) during the months of May through September

Objective
The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction
Skunk Creek is a 74.3 mile stream with a watershed of approximately 372,571 acres and is a tributary of the Big Sioux River in southern Minnehaha County. This watershed lies within Moody, Lake, and Minnehaha Counties as shown by the shaded region in Figure 1 (includes LMUs 15, 16, 17, 18, 19, 20, 21, 22, 23, V, Y, BB, and II) and is included as part of the Central Big Sioux River Watershed Assessment Project. The entire study area for this project is also outlined in Figure 1. Skunk Creek was identified as having insufficient information to determine support status for limited contact recreation for the 2006 303(d) Waterbody list.

Skunk Creek is influenced by the tributaries of North Buffalo Creek, Brant Lake Outlet, Buffalo Creek, Willow Creek, West Branch Skunk Creek, and Colton Creek. The Central Big Sioux River Watershed Assessment Project has identified Skunk Creek for TMDL development due to not meeting the water quality criteria for fecal coliform bacteria. Information supporting this listing was derived from East Dakota Water Development District monitoring data. Skunk Creek was listed in the 2006 303(d) State Waterbody list has having insufficient information to determine support status for limited contact recreation beneficial use. Appendix B of the Assessment Report summarizes the data collected during the period of June 2000 to September 2001.

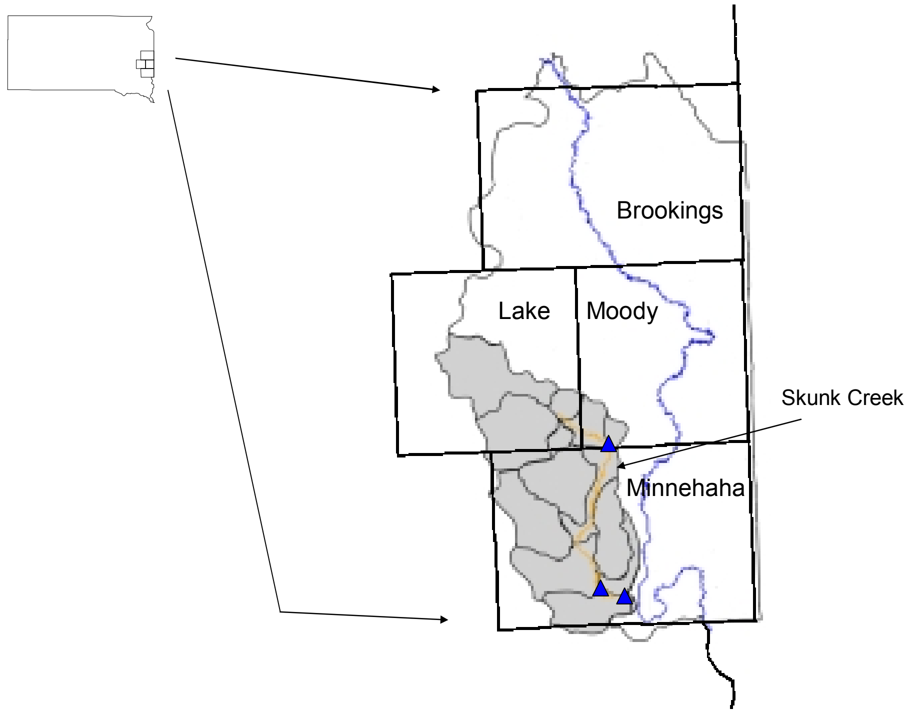


Figure 1. Location of the Skunk Creek Watershed in South Dakota

Problem Identification

Skunk Creek begins in south-eastern Lake County, runs through south-western Moody County, and then joins the Big Sioux River in south-central Minnehaha County. The three monitoring sites setup on this tributary include T18, T21, and T23. The watershed area shown in Figure 2 drains approximately 94 percent grass/grazing land and cropland acres. The municipalities of Hartford, Crooks, Colton, Chester, and Humboldt are located within this watershed.

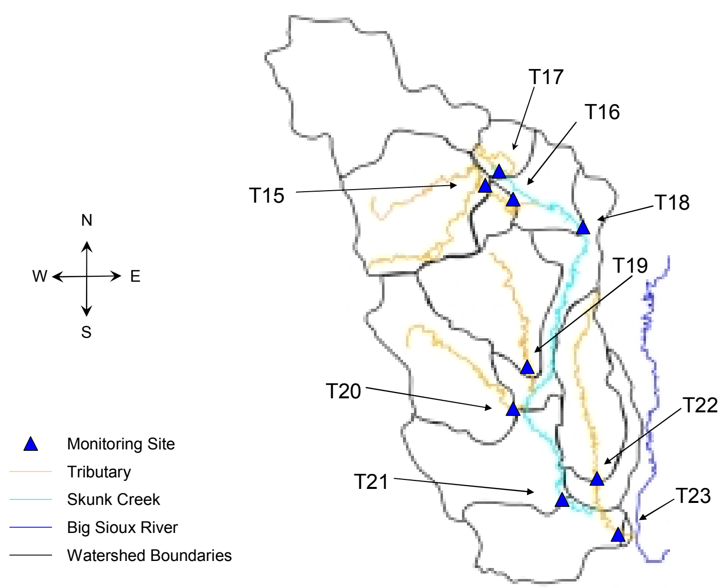


Figure 2. Skunk Creek Watershed

Skunk Creek was found to carry fecal coliform bacteria which degrades water quality. This stream is considered impaired because more than 10 percent of the values (of 20 or more samples) exceeded the numeric criteria of ≤ 2,000 counts per 100 milliliters of fecal colifom bacteria during the season of May 1 to September 30. Table 1 displays the fecal coliform data collected from June 2000 to September 2000 and from May 2001 to September 2001.

Table 1. Summary of Fecal Coliform Data for Skunk Creek

Parameter Causing Impairment	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Fecal Coliform	35	28.6	40	134,000

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Skunk Creek has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations (See page 12 of the Assessment Report). Along with these assigned uses are narrative and numeric criteria that define the desired water quality of this stream. These criteria must be maintained for the stream to satisfy its assigned beneficial uses, which are listed below:

- Warmwater marginal fish life propagation
- Limited contact recreation
- Fish & wildlife propagation, recreation & stock watering
- Irrigation

Individual parameters determine the support of beneficial uses. Use support for limited contact recreation involved monitoring the levels of fecal coliform from May 1 through September 30. This stream experiences fecal coliform loading due to poor riparian areas, stormwater runoff, and NPDES facilities. Administrative Rules of South Dakota Article 74:51 contains numeric and narrative standards to be applied to the surface waters (i.e. streams, rivers) of the state. To assess the status of the beneficial uses for this stream, water samples were obtained using SD DENR standard operating procedures and the results were compared to the applicable water quality criteria.

Skunk Creek is currently assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. A flow duration interval with hydrologic zones approach was used to assess this stream. This methodology, developed by Bruce Cleland, was used in order to target restoration efforts by dividing the range of flows into hydrologic conditions (Cleland 2003). For example, if all of the exceedences occurred during low flow conditions, point sources of the pollutant should be suspected. Conversely, if all the exceedences occurred during higher flow periods, then non-point sources of pollution should be suspected. Using Clelands's approach the following five hydrologic conditions were utilized: High Flows (0-10 percent), Moist Conditions (10-40 percent), Mid-Range Flows (40-60 percent), Dry Conditions (60-90 percent), and Low Flows (90-100 percent). The methodology of flow duration intervals is explained further in the Methods Section of the Assessment Report.

Three monitoring locations were setup on Skunk Creek (T18, T21, and T23). Of the 35 water samples that were collected, 10 (or 28.6 percent) violated the water quality standards for fecal coliform bacteria. Based on the water quality violations, Skunk Creek does not currently support its assigned beneficial use of Limited Contact Recreation.

Each of the tributaries affecting this creek was assessed for their level of fecal coliform loading. Brant Lake Outlet (T17) was the only one, of six tributaries, with an assigned numeric standard for fecal coliform bacteria. However, all tributaries were assessed at ≤ 2,000 cfu/100mL numeric standard (Table 2).

Table 2. Summary of Fecal Data for Tributaries Within the Watershed of Skunk Creek

Monitoring Location	Number of Samples (May-Sep)	Percent of Samples > 2000 counts/100mL	Minimum Concentration (counts/100mL)	Maximum Concentration (counts/100mL)
Brant Lake Outlet (T17)	10	20.0	80	9,800
* North Buffalo Creek (T15)	11	54.5	99	16,000
* Buffalo Creek (T16)	8	12.5	50	2,200
* Colton Creek (T19)	11	81.8	300	210,000
* West Branch Skunk Creek (T20)	11	54.5	800	160,000
* Willow Creek (T22)	12	41.7	70	60,000

* numeric standard not applicable

Brant Lake Outlet is currently supporting its assigned beneficial uses at the current numeric standard of ≤ 2,000 cfu/100mL and does not require a reduction.

At ≤ 2,000 cfu/100mL, North Buffalo Creek (T15) would need reductions during high flows/moist conditions and mid-range/dry conditions.

Buffalo Creek (T16) is not assigned a numeric standard, nor does it need a reduction in fecal coliform loading at the ≤ 2,000 cfu/100mL standard.

Colton Creek (T19) would need reductions during high flows/moist conditions and dry/low flow conditions.

Both Willow Creek (T22) and West Branch Skunk Creek (T20) would need reductions throughout their overall respective flowzones.

Figure 3 depicts the flow of water within the watershed and also shows the municipalities located within the watershed.

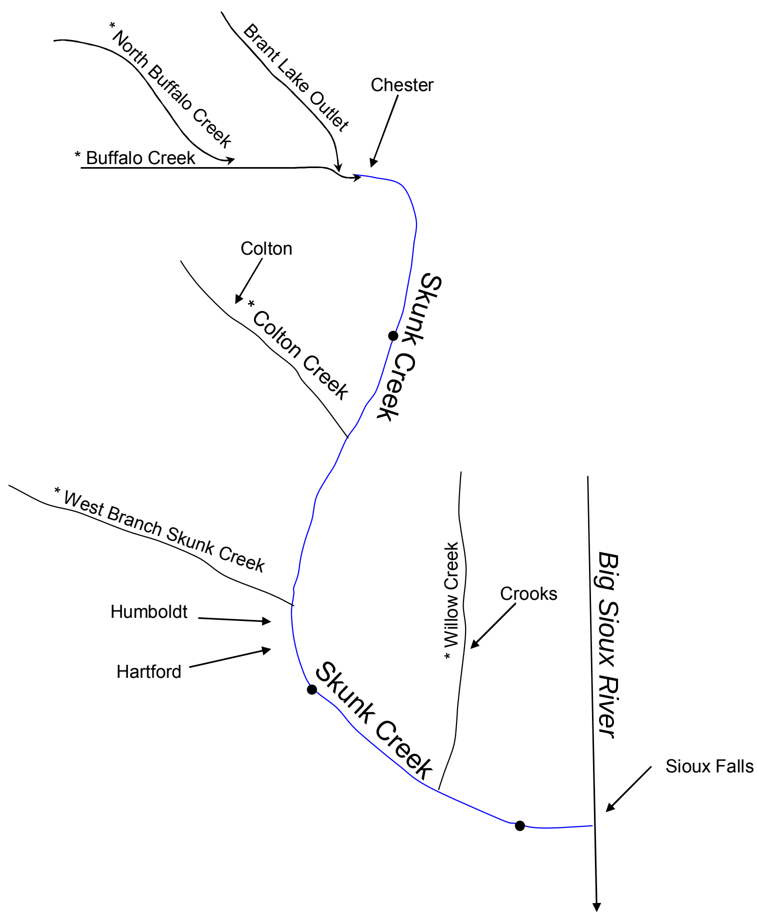


Figure 3. Water Flow in the Skunk Creek Watershed

This is a unique situation due to the fact that Skunk Creek and Brant Lake Outlet require a numeric criteria evaluation at ≤ 2,000 cfu/100mL and all other tributaries are not assigned numeric standard. However, according to Rule **74:51:01:04 Application of criterion to contiguous water** states,

> *"If pollutants are discharged into a segment and the criteria for that segments designated beneficial use are not exceeded but the waters flow into another segment whose designated beneficial use requires a more stringent parameter criterion, that pollutants may not cause the more stringent criteria to be exceeded."*

This basically means if one body of water runs into another body of water with a more stringent standard, the more stringent standard would apply to all waters of concern. In this case, Skunk Creek is assigned a numeric standard of ≤ 2,000 cfu/100mL for fecal coliform bacteria. According to Rule **74:51:01:04**, in order to meet the goals for this stream, all received waters must also meet the ≤ 2,000 cfu/100mL numeric criteria for fecal coliform bacteria. Due to this situation, the five tributaries that are currently not assigned a numeric standard must be evaluated at the ≤ 2,000 cfu/100mL standard to meet the goals of the Skunk Creek TMDL. Reduction of fecal coliform loads to these tributaries would greatly affect the fecal coliform bacteria reduction to Skunk Creek. Therefore, improvement to water quality in the fore mentioned tributaries is necessary.

Pollutant Assessment

Point Sources

The NPDES facilities taken into consideration within this area are Dakota Ethanol, Tri-Valley School District, Crooks Water and Sewer, Wall Lake Sanitary District, and the Cities Colton, Chester, Humboldt, and Hartford (Table 3). The City of Hartford was the only facility that contributed to the fecal coliform load during the study period. This facilities contribution was insignificant at 0.00001 percent of the fecal load. It should be noted that this facility recorded several high daily discharges. The City of Colton and Crooks Water and Sewer discharged during the study period but no fecal data was recorded. The remaining facilities either did not discharge during the study period or maintained total retention. Calculations used total colonies from all the facilities divided by the total colonies at Site T21 (Site T21 was used because the City of Hartford discharged). The numbers shown in Table 3 are the potential load that could be delivered to Skunk Creek.

Table 3. NPDES Facilities.

Facility Name	Permit Number	# colonies/day
Chester	SD0020338	2.16E+10
Colton	SD0022322	0
Crooks	SD0020761	3.03E+10
Dakota Ethanol	SD0027847	0
Hartford	SD0021750	3.89E+10
Humboldt	SDG824015	0
Tri-Valley	SDG827278	0
Wall Lake Sanitary District	SD0026778	0

Non-point Sources

Non-point source pollution, unlike pollution from municipalities and NPDES, comes from many diffuse sources. Potential non-point sources of fecal coliforms include loadings from surface runoff, wildlife, livestock, pets, and leaking septic tanks.

Wildlife

Wildlife deposit their feces onto land surfaces and in some cases directly into the water. The bacterial load from naturally occurring wildlife is assumed to be background. In addition, any strategy employed to control this source would probably have a negligible impact on attaining water quality standards.

Agricultural

Agricultural animals are the source of several types of non-point sources as indicated in the Future Recommendations section of the Assessment Report. Agricultural activities including runoff from pastureland and cattle in streams, can affect water quality. Livestock data collected during AGNPS Feedlot modeling are listed in Table 4.

Table 4. Livestock in the Skunk Creek Watershed

Livestock Distribution	North Buffalo Creek	Buffalo Creek	Colton Creek	Willow Creek	Skunk Creek	West Branch Skunk Creek
Beef Cattle/Calves	2610	740	4211	4517	12342	6511
Hogs/Pigs	280	50	1650	200	1790	290
Dairy Cattle	----	----	146	80	1031	350
Horses	----	----		30	12	127
Sheep	----	----	60	----	530	11100
Buffalo	----	----	----	----	300	----

Septic Systems

Data for septic tanks is discussed in the Assessment Report on page 72. Contributions from septic systems were estimated based on rural households because a direct accounting of the number of septic systems in use in the TMDL watershed was unavailable. The 18.2 percent contribution from septic systems was determined by assuming all rural septic systems in the Central Big Sioux Watershed were failing. This percentage does not account for die-off or attenuation of fecal coliform bacteria between failing septic systems and the stream. In general, failing septic systems discharge over land for some distance, where a portion of the fecal coliform bacteria may be absorbed on the soil and surface vegetation before reaching the stream. It is assumed that failing septic systems constitute a diminutive amount of the overall contribution because not all systems would be failing. These results will not be used directly in the TMDL allocations and will not affect the TMDL determination and allocation. Therefore; it is implied that comparatively, failing septic systems are having an insignificant affect on the excess fecal coliform loading and will be contributed to the margin of safety for the TMDL.

Urban Areas

Fecal coliform bacteria in urban and suburban areas may be attributed to stormwater runoff, overflow of sewer systems, illicit discharge of sanitary waste, leaking septic systems, and pets.

Land Use

Landuse in the watershed was derived from the Sediment Delivery Model. Table 5 shows that 94 percent of the area is grass or cropland. Urban areas would fall into the artificial category, which makes up approximately one percent of the watershed.

Table 5. Landuse in the Skunk Creek Watershed

LandUse	Percent	Acres
Water	3%	9,687
Trees	2%	7,451
Artificial	1%	2,608
Barren	0%	373
Grass	28%	105,065
LEP Cropland	50%	187,031
MEP Cropland	9%	34,277
HEP Cropland	7%	26,080

LEP = Low Erosion Potential
MEP = Medium Erosion Potential
HEP = High Erosion Potential

Linkage Analysis

Water quality data was collected at three monitoring sites on Skunk Creek, five tributary sites, and one lake outlet. Samples were collected according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were analyzed by the Water Resource Institute, at South Dakota State University in Brookings, South Dakota and also by the Sioux Falls Health Lab in Sioux Falls, South Dakota. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Non-point Source Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the assessment final report.

The Flow Duration Interval Zone method calculates fecal coliform bacteria loading, (concentration) x (flow), using zones based on hydrologic conditions. Reductions are calculated using the median of the fecal coliform bacteria samples in each zone. This method shows that while a TMDL may be expressed as a single point it can also be thought of as a continuum of points representing the criterion value and various flow values. In order to assess the impact of fecal coliform bacteria for Skunk Creek, the range of flows from each of the three monitoring locations were merged to form the flow duration interval curve and were then divided into "flow zones". The purpose of the zones is to differentiate hydrologic conditions, between peak and low flows, as ranges. For this tributary, the ranges or flow zones are High Flows (0-10), Moist Conditions (10-40), Mid-Range Flows (40-60), Dry Conditions (60-90), and Low Flows (90-100). Load duration curves were calculated using the following equation:

(flow) × (conversion factor) × (state criteria) = quantity/day or daily load

This curve represents the threshold of the load. As seen in Figure 4, any samples occurring above this line are an exceedence of the water quality standard (≤ 2,000 cfu/100mL) and represented by a red box (See Attachment 1 for details). Table 6 depicts the allowable coliform bacteria load during the study for peak flow, low flow, and 5th percentile increments in flow. Flow duration intervals and exceedence tables for each of the tributaries influencing this stream can be found in Attachment 2.

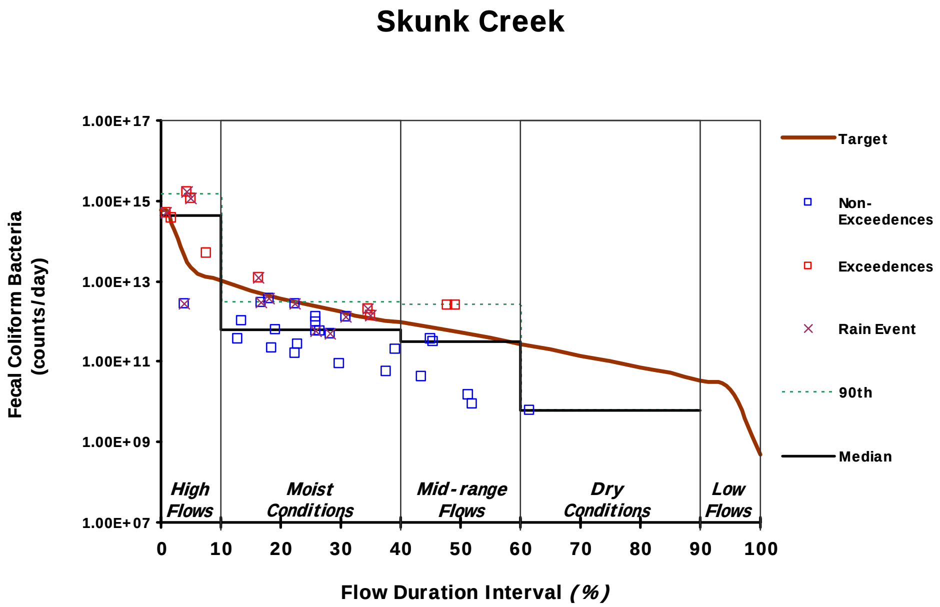


Figure 4. Flow Duration Interval for Skunk Creek at ≤ 2,000 cfu/100mL

Table 6. Fecal Coliform Target Loads for Flow

Flow Rank (percent)	cfs	Allowable Loads 2000 cfu/100mL Fecal Coliform (counts/day)	Flow Conditions
0.019	12388.00	6.06E+14	Peak
0.100	11708.00	5.73E+14	
0.274	11543.00	5.65E+14	
1	11500.00	5.63E+14	
5	441.00	2.16E+13	
10	208.00	1.02E+13	
15	121.00	5.92E+12	
20	76.00	3.72E+12	
25	50.15	2.45E+12	
30	35.00	1.71E+12	
35	25.00	1.22E+12	
40	20.00	9.79E+11	
45	15.00	7.34E+11	
50	11.00	5.38E+11	
55	7.80	3.82E+11	
60	5.60	2.74E+11	
65	4.00	1.96E+11	
70	2.90	1.42E+11	
75	2.10	1.03E+11	
80	1.50	7.34E+10	
85	1.10	5.38E+10	
90	0.70	3.43E+10	
95	0.40	1.96E+10	
100	0.01	4.89E+08	Low

The Agricultural Non-Point Source Pollution (AGNPS) model is a GIS-integrated water quality model that predicts non-point source loadings within agricultural watersheds. ArcView GIS software was used to spatially analyze animal feeding operations and their pollution potential. The feedlot assessment assumed the probable sources of fecal coliform bacteria loadings within the CBSR watershed were agricultural related and rated the feedlots based on runoff potential. Feedlot ratings ranged from 0-102. The 68 feedlots that rated 50 or greater are listed in Table 7 by number and LMU. A rating of 50 or greater warrants concern in regards to potential pollution problems (See Attachment 3 for a more detailed table). A map identifying those regions of concern is shown in Figure 5. A complete methodology report can be found in Appendix CC of the Assessment Report.

Table 7. Feedlot Ratings ≥ 50 for the Skunk Creek Watershed

LMU	# of Feedlots Rated ≥ 50
15	six
16	one
19	fourteen
20	twelve
21	thirteen
22	nine
23	one
Y	ten
BB	two

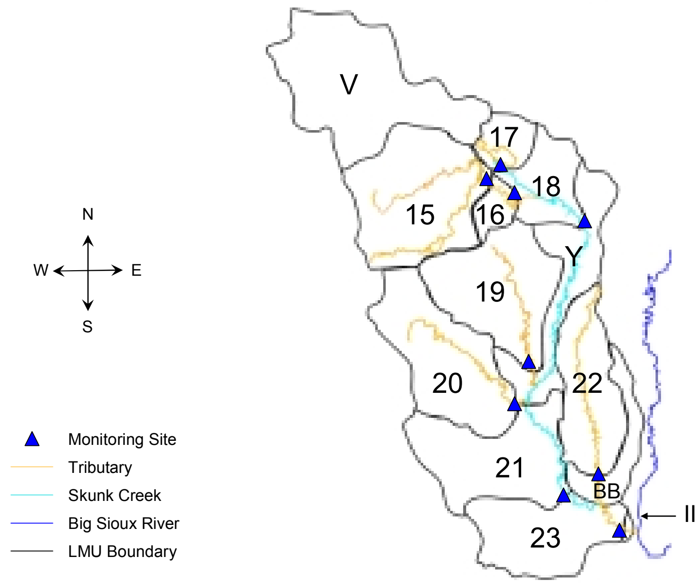


Figure 5. LMUs of the Skunk Creek Watershed

TMDL and Allocations

TMDL

Segment ID	Name	TMDL Component	Duration Curve Zone (Expressed as counts/day)			
			High	**Moist**	**Mid-Range**	**Dry**
		TMDL	2.16E+13	2.45E+12	5.38E+11	1.03E+11
		10% MOS	2.16E+12	2.45E+11	5.38E+10	1.03E+10
		Total Allocations	1.94E+13	2.21E+12	4.84E+11	9.27E+10
		LA	1.93E+13	2.11E+12	3.93E+11	1.90E+09
	Wall Lake	WLA	0	0	0	0
	Dakota Ethanol	WLA	0	0	0	0
SD-BS-R-SKUNK_01	**Humboldt**	WLA	0	0	0	0
	Hartford	WLA	3.89E+10	3.89E+10	3.89E+10	3.89E+10
	Crooks	WLA	3.03E+10	3.03E+10	3.03E+10	3.03E+10
	Colton	WLA	0	0	0	0
	Chester	WLA	2.16E+10	2.16E+10	2.16E+10	2.16E+10
	Tri-Valley	WLA	0	0	0	0
		Background	3.87E+11	4.23E+10	7.87E+09	3.80E+07
		Other NPS	1.90E+13	2.07E+12	3.86E+11	1.86E+09

Wasteload Allocations (WLAs)

NPDES facilities are permitted to discharge effluent at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations. Their contributions are relatively small in comparison to the total loading of the segment. The worst case scenario of all point source waste loads within this segment would be approximately 9.08×10^{10} fecal counts if all facilities discharged their maximum amount at the same time. This amount is unlikely since most dischargers operate well within their permit limits and discharge smaller loads than allowed. In order to find the TMDL, the waste load allocation (point source) was added to the allowable load (non-point source) and a 10 percent margin of safety was applied. New or increases in discharges affecting this segment will be required to meet bacterial standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards. Identified point sources in this watershed are contributing an insignificant amount to the fecal coliform loading. Therefore, the “wasteload allocation” component is of no consequence, as indicated in the above TMDL.

Load Allocations (LAs)

Load allocations account for the portion of the TMDL assigned to non-point sources. Natural background constitutes two percent of the total and the remainder of the LA is assigned to those land uses likely to contribute fecal coliform bacteria loads at rates above natural background. This includes cropland, pastureland, and residential areas. Based on the flow duration interval method, a 95 percent reduction is needed from non-point sources during high flow conditions (refer to Figure 4), as shown in Table 2.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. When a rainfall event occurs, fecal coliform bacteria that have built up on the land surface under dry conditions are washed off and finally deposited into lakes, rivers, and wetlands. To determine seasonal differences, runoff events were noted for the East Dakota Water Development District samples. Of the samples collected at T18, T21, and T23, that were exceeding the standard (≤ 2,000 cfu/100 mL), 62 percent were during rain events (See Appendix B of the Assessment Report for EDWDD samples).

Margin of Safety

The margin of safety (MOS) is a portion of the loading capacity that is set aside to prevent the exceedence of a water quality standard as a means of accounting for the uncertainty involved in developing a TMDL. The MOS for this TMDL is explicit, meaning a specific quantity, in this case 10%, of the loading is set aside. This explicit MOS takes into consideration the uncertainties associated with flow and non-point sources.

Critical Conditions

The critical condition for fecal coliform loadings in any watershed depends on the presence of point sources and land use within that watershed. During a dry period, typically the critical condition is non-point sources followed by a rainfall event. During the rainfall event, fecal coliform bacteria that have built up on the land surface can wash into the stream, causing wet weather exceedences.

Follow-Up Monitoring

Monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and include the parameter of fecal coliform bacteria. Once the implementation project is completed, post-implementation monitoring will be necessary to assure that the TMDL has been reached and improvement to the beneficial uses occurs. This will be achieved by recurrent water quality sampling at the original monitoring sites.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. East Dakota Water Development District monthly board meetings
2. Field demonstrations for the public
3. Articles in the local newspapers

The findings from these public meetings and comments have been taken into consideration in development of the Skunk Creek TMDL

Implementation Plan

The TMDL analysis was performed using the best data available to specify the fecal coliform reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications of this segment. A detailed implementation plan is not included in this TMDL. The involvement of local land owners and agencies will be needed in order to develop and implementation plan. In general, reductions in fecal coliform bacteria should be sought through identification and installation of agricultural BMPs to reduce loads during runoff events.

To guide implementation efforts the existing condition was calculated by multiplying the median concentration by the median of the flow from each flowzone. The target load is the median of the flow multiplied by the numeric standard (≤ 2,000 cfu/100mL) for fecal coliform bacteria. The percent reduction is the difference between the existing and target load with a 10% MOS for uncertainties due to variation in flow. Using this baseline, this stream requires reducing the fecal coliform counts per day by 95 percent during high flow conditions (Table 8). Additional controls may be needed in order to achieve the applicable water quality standards and meet the TMDL goal for this segment as the median concentration is used here as a starting point.

Table 8. Skunk Creek Fecal Coliform Reductions

	Median	High (0-10)	Moist (10-40)	Mid-Range (40-60)	Dry (60-90)	Low (90-100)
	Median Concentration (counts/day)	9.84E+11	1.24E+10	2.85E+10	2.91E+09	-------
X	Flow Median (cfs)	441	50.15	11	2.1	0.4
=	Existing	4.34E+14	6.21E+11	3.14E+11	6.12E+09	-------
	Target Load (at 2,000 cfu/100mL)	2.16E+13	2.45E+12	5.38E+11	1.03E+11	1.96E+10
	% Reduction w/MOS	95	0	0	0	-------

Note: units are counts/day

Each of the tributaries affecting this creek was assessed for their level of fecal coliform loading. Brant Lake Outlet (T17) was the only one, of six tributaries, with an assigned numeric standard for fecal coliform bacteria. However, all tributaries were assessed at ≤ 2,000 cfu/100mL numeric standard (Table 9). The reductions shown in Table 9 are based on the median concentration from each flowzone.

Table 9. Fecal Coliform Bacteria Reductions for Tributaries of Skunk Creek at the ≤ 2,000 cfu/100mL

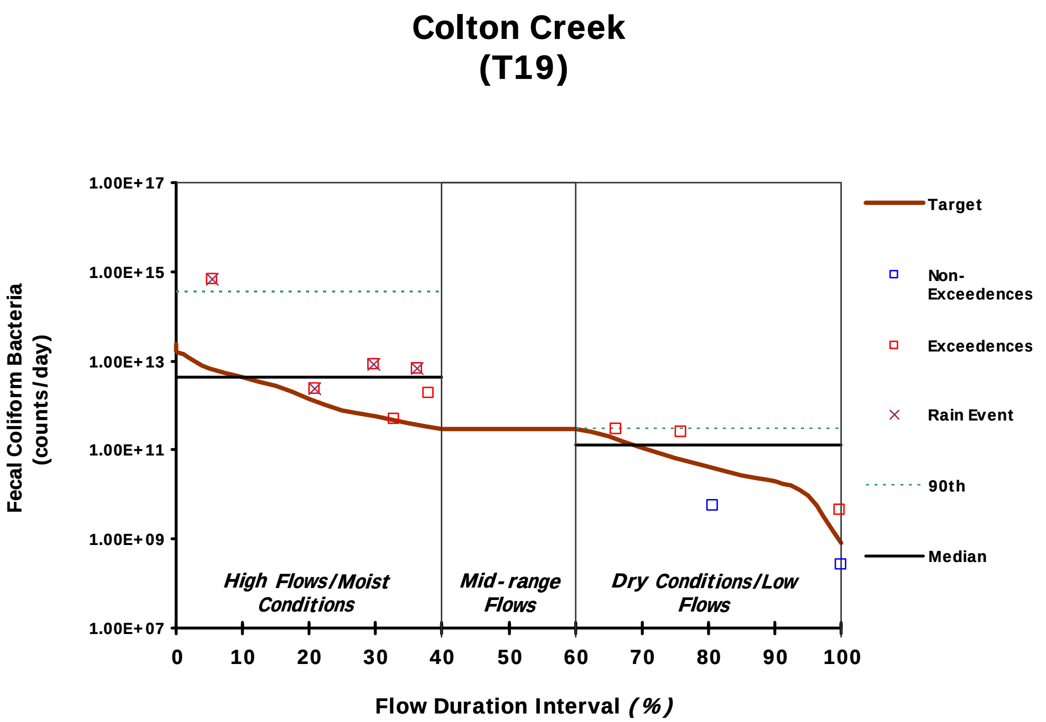
Percent Reduction with MOS			
2000 cfu/100mL	**High/Moist (0-40)**	**Mid-Range (40-60)**	**Dry/Low (60-100)**
* Colton Creek	70	-----	71
	High/Moist (0-40)	**Mid-Range/Dry (40-90)**	**Low Flows (90-100)**
* North Buffalo Creek	95	37	0
	Overall Conditons (0-100)		
* Buffalo Creek	0		
Brant Lake Outlet	0		
* W. Branch Skunk Creek	49		
* Willow Creek	48		
* Denotes no numeric standard assigned			

Fecal Exceedences for Skunk Creek

Station	Sample Date	Sample Time	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T23	06/13/01	1500	506.00	0.0429	4.29	134000	1.66E+15
T21	06/13/01	1300	438.16	0.0506	5.06	106000	1.14E+15
T21	05/07/01	1230	922.82	0.0183	1.83	16000	3.61E+14
T23	05/07/01	1130	1380.00	0.0090	0.90	15000	5.07E+14
T18	09/18/00	1100	11.65	0.4908	49.08	9100	2.60E+12
T18	08/14/00	1400	12.80	0.4783	47.83	8300	2.60E+12
T18	06/13/01	1045	283.42	0.0757	7.57	7000	4.85E+13
T23	07/23/01	1315	106.00	0.1626	16.26	4600	1.19E+13
T23	07/10/00	1545	26.00	0.3459	34.59	3200	2.04E+12
T18	07/23/01	1000	25.76	0.3490	34.90	2200	1.39E+12

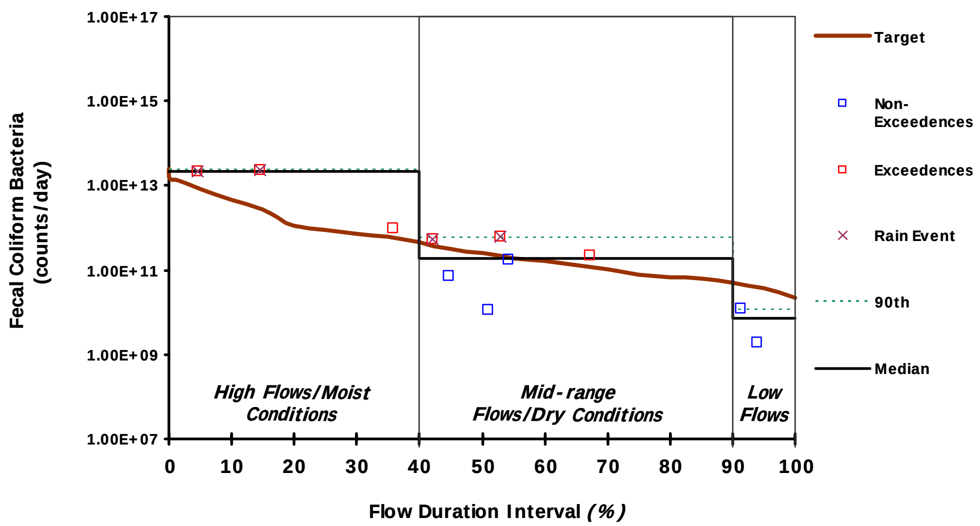
Fecal Exceedences and Flow Duration Intervals for the Tributaries Influencing Skunk Creek (at 2000 cfu/100mL)

Station	Sample Date	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T19	06/13/01	136.69	0.0535	5.35	210000	7.02E+14
T19	07/23/01	6.99	0.3621	36.21	38000	6.50E+12
T19	07/13/00	12.18	0.2975	29.75	29000	8.64E+12
T19	07/09/01	5.90	0.3794	37.94	13000	1.88E+12
T19	08/14/00	1.23	0.7585	75.85	8700	2.61E+11
T19	09/18/00	0.04	0.9970	99.70	4600	4.50E+09
T19	05/07/01	25.21	0.2080	20.80	3700	2.28E+12
T19	06/12/00	3.43	0.6606	66.06	3600	3.02E+11
T19	06/04/01	9.91	0.3273	32.73	2100	5.09E+11

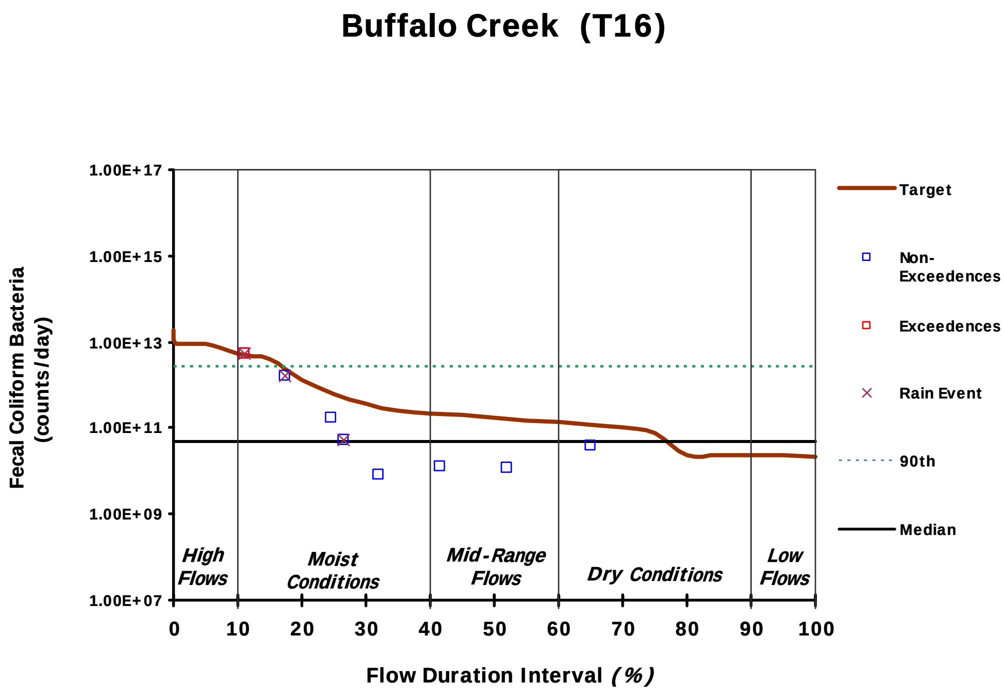


Station	Sample Date	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T15	06/13/01	59.29	0.1455	14.55	16000	2.32E+13
T15	08/17/00	4.42	0.5291	52.91	5800	6.27E+11
T15	05/07/01	182.71	0.0458	4.58	4700	2.10E+13
T15	08/14/00	2.57	0.6734	67.34	3400	2.14E+11
T15	06/12/00	12.36	0.3575	35.75	3100	9.38E+11
T15	07/12/00	7.92	0.4205	42.05	2800	5.42E+11

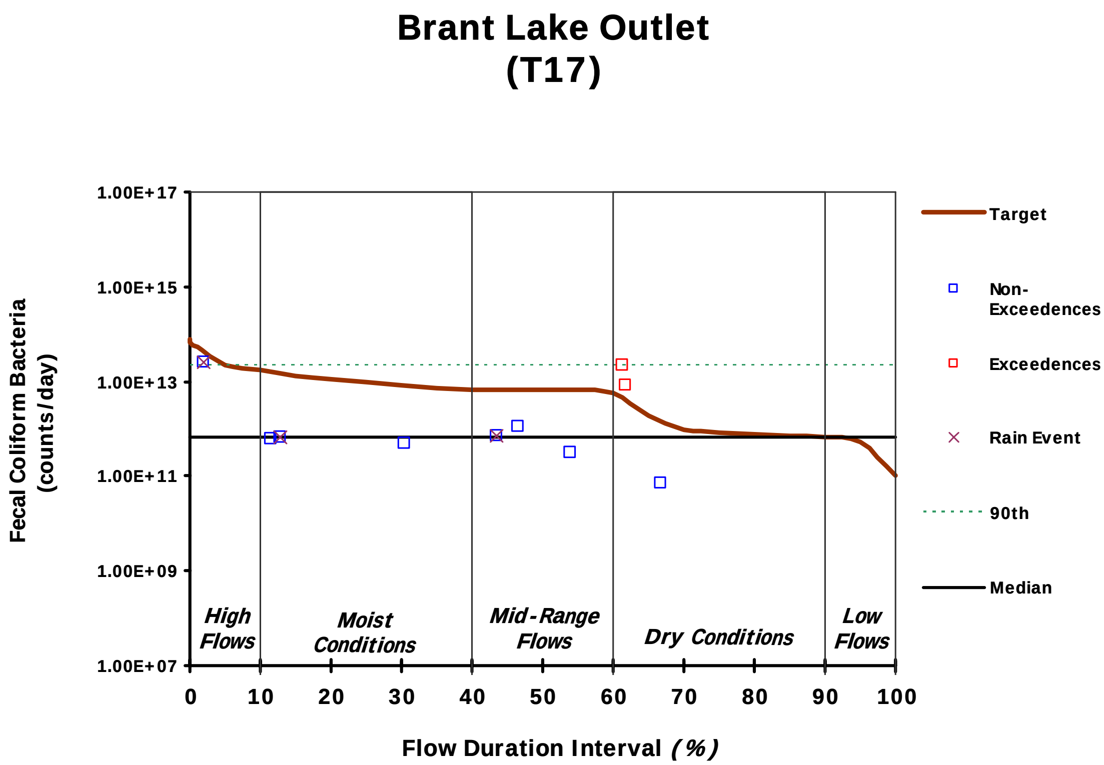
North Buffalo Creek (T15)



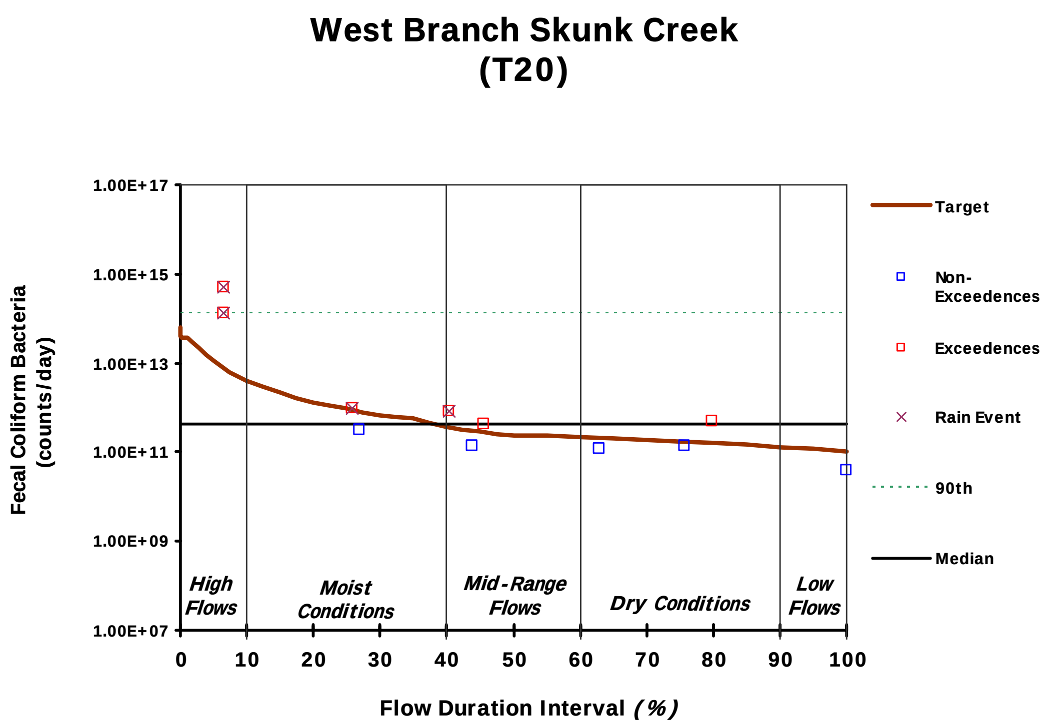
Station	Sample Date	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T16	05/07/01	99.00	0.1118	11.18	2200	5.33E+12



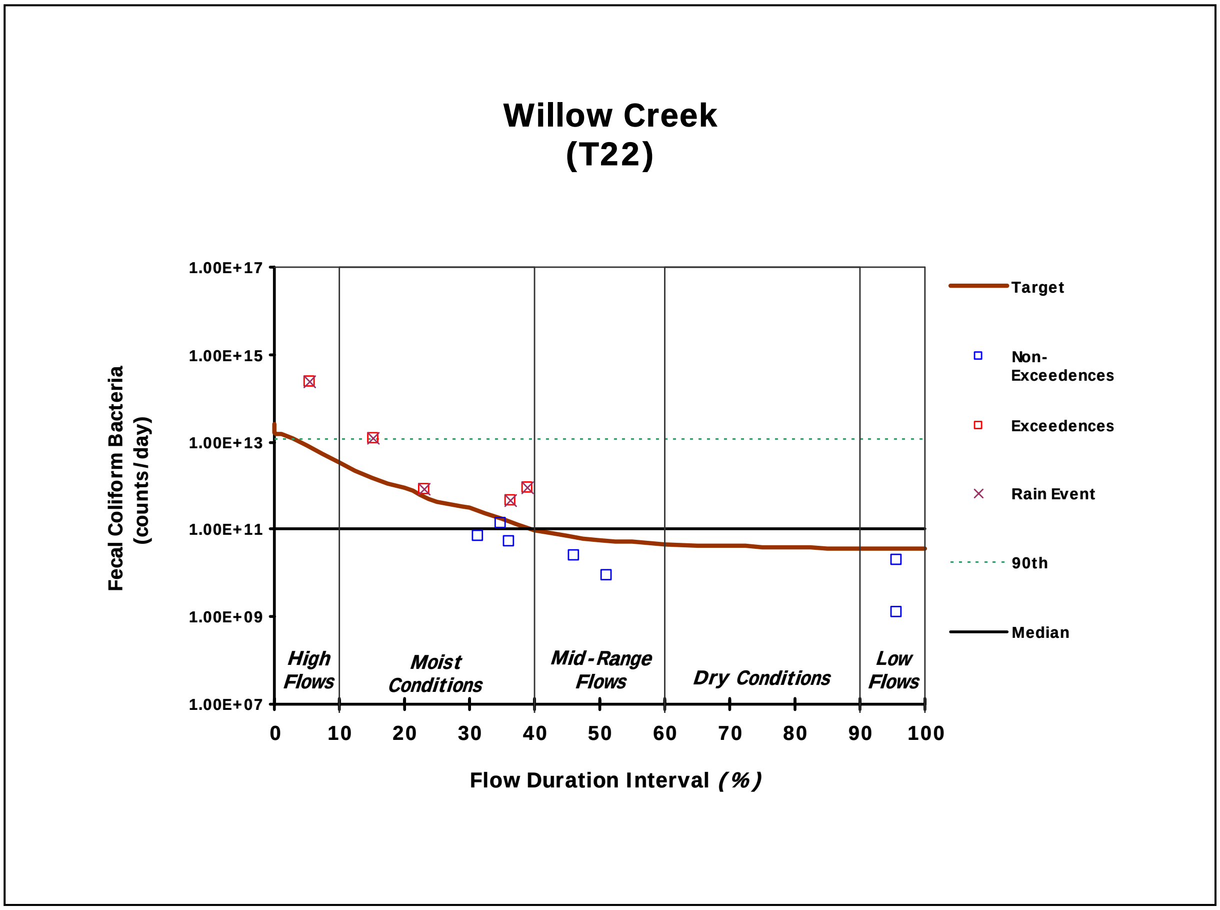
Station	Sample Date	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T17	09/18/00	89.32	0.6130	61.30	9800	2.14E+13
T17	08/14/00	86.36	0.6170	61.70	4000	8.45E+12



Station	Sample Date	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T20	05/07/01	133.05	0.0660	6.60	160000	5.21E+14
T20	06/13/01	140.20	0.0645	6.45	37000	1.27E+14
T20	08/14/00	3.27	0.7977	79.77	6300	5.04E+11
T20	07/23/01	7.61	0.4035	40.35	4400	8.19E+11
T20	06/12/00	5.64	0.4555	45.55	3100	4.28E+11
T20	07/13/00	18.90	0.2585	25.85	2100	9.71E+11



Station	Sample Date	Flow (cubic feet per second - cfs)	Flow Rank	Flow Rank (percent)	Fecal Coliform (counts/100mL)	Fecal Coliform Load (counts/day)
T22	06/13/01	166.85	0.0545	5.45	60000	2.45E+14
T22	05/07/01	30.26	0.1529	15.29	17000	1.26E+13
T22	07/23/01	2.29	0.3902	39.02	16000	8.97E+11
T22	07/10/00	2.90	0.3639	36.39	6500	4.61E+11
T22	07/13/00	11.12	0.2312	23.12	3000	8.17E+11



Feedlot Rating by LMU

LMU	Feedlot Rating
15	50
15	62
15	64
15	66
15	72
15	99
16	73
19	50
19	50
19	53
19	54
19	56
19	56
19	57
19	59
19	62
19	63
19	65
19	69
19	85
19	92
20	51
20	56
20	59
20	60
20	61
20	65
20	67
20	69
20	72
20	78
20	78
20	94
21	52

LMU	Feedlot Rating
21	58
21	61
21	62
21	64
21	66
21	68
21	73
21	75
21	79
21	79
21	93
21	97
22	53
22	54
22	56
22	61
22	68
22	68
22	75
22	82
22	84
23	68
Y	53
Y	55
Y	56
Y	58
Y	58
Y	61
Y	61
Y	66
Y	68
Y	75
BB	52
BB	74

Appendix GGG.
Central Big Sioux TMDLs EPA/Public Comments
DENR Response to Comments

Central Big Sioux River TMDLs

- The Introduction section (p. 1), the body of the assessment report and the individual TMDLs should be updated to reflect the most recent listing information from the 2006 303(d) list. Also, each individual TMDL (i.e., Appendix SS – FFF) should include the State's assessment unit ID(s) for the segment(s) covered, and a statement as to whether the segment covered by the TMDL is on the 2006 303(d) list or not.

SDDENR Response - The assessment unit IDs have been added to each segment and language has been added to reflect the 2006 IR. Assessment unit IDs for the smaller waterbodies not specifically listed in the 2006 IR were created and added to the TMDL language.

EPA comment: OK

- The Urban Stormwater Runoff section (p. 39) is almost completely a discussion of the MS4 discharge from Sioux Falls. MS4 discharges are point sources by definition; therefore, the paragraphs in this section should be moved to the Point Source section. Also, the point source section needs to be expanded to include discussion of the MS4 discharges from the City of Brookings (see below).

SDDENR Response - The sections related to MS4 dischargers were moved into the appropriate sections.

EPA comment: OK

- The Assessment of Sources section (p. 38) as well as Appendix SS refers to stormwater contributions from the City of Brookings. Both sections include this source in the non point source grouping. The City of Brookings has a municipal separate storm sewer system (MS4) permit from SD DENR for their stormwater discharges. This makes the stormwater fecal coliform and TSS contributions from Brookings a point source according to the various EPA regulations and guidance. Subsequently, this source needs to be included in the Point Source section of the assessment report and in the TMDL for the segment of the Big Sioux River that includes the City of Brookings (i.e., Appendix SS; TMDL for the Big Sioux River from Brookings to I-29). Also, the TMDL for this segment needs to include a separate WLA for stormwater for the City of Brookings in accordance with EPA's guidance (See EPA's memorandum: "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs," November 22, 2002 - http://www.epa.gov/npdes/pubs/final-wwtmdl.pdf). Also, the TMDL should be clear on whether the City of Brookings will need to reduce their fecal coliform or TSS loading from stormwater.

SDDENR Response – When the TMDL was initiated an MS4 Phase II was not necessary. Brookings was not included as an MS4 because of this. However, with the existing flow and loading data, as part of this assessment, DENR can allocate a WLA to city of Brookings for their MS4. However, at this time the City of Brookings has not been contacted regarding the potential TSS and Fecal WLA for their MS4 permit for the Brookings to I-29 segment and Six Mile Creek TMDLs, respectively. Until the city has been given time to comment on these WLAs, these two TMDLs (TSS TMDL for Brookings to I-29 and Fecal TMDL for Six Mile Creek) will be withheld for final approval at this time.

EPA comment: OK. DENR asked if EPA would approve TMDLs for waterbodies that were fully supporting. Ruppel made the comment that the Clean Water Act requires a TMDL for every waterbody and every pollutant even if it is not impaired but the focus now is on impaired waterbodies. Yes, they will approve TMDLs for waterbodies that are fully supporting.

- The Assessment of Sources section (p. 68) includes tables that list the NPDES percent contributions of TSS and fecal coliform. However, neither these tables nor the individual TMDLs list the WLAs, as a daily load, for each one of the discharging facilities. As a result of the TMDL program's evolution and issues related to the Anacostia lawsuit, EPA must now have the NPDES permit numbers and WLAs for each TMDL approval. We must subsequently enter that information into our national TMDL tracking system. The loading tables in each TMDL need to be revised to include the individual WLA for each point source discharge that is contributing a load to that segment, rather than the combined WLA as is currently included

(See Tables 2-2 and 5-4 in EPA's Aug 2007 load duration curve guidance. The full reference is given below).

SDDENR Response - The Table 30 (pg 68) includes average flow and concentration, which are used to calculate the daily pounds per day. These numbers are used in each TMDL to calculate a daily WLA under the Section TMDL and Allocations. A note under each table states that the units are in pounds per day. DENR has added the permit numbers and individual WLA for each TMDL.

EPA response: OK

- The Dissolved Oxygen section of the report (p. 56) says that the dissolved oxygen criteria are not being met in 3 river sites (i.e., R09-R11) and 5 tributary sites (i.e., T01, T05, T24, T31 and T32). It is not clear from the document whether or not TMDLs will be developed for these 8 sites identified as not meeting the DO criteria. On page 162 of the report it says that not enough data exists to conclude that Silver Creek has a DO problem and that more data is needed. Is the conclusion the same for the other seven sites that are not meeting the dissolved oxygen criteria?

SDDENR Response - New data shows these mainstem segments are not impaired for dissolved oxygen. During the assessment, although there were exceedances of the DO standard, the listing criteria was not exceeded. However, with the upcoming reassessment of the segments within the city of Sioux Falls, DENR will include all of the water quality standard parameters in the monitoring plan. Language was added to show that although the DO standard was exceeded no TMDLs were required.

The tributary sites fell into same situation with the exception of Silver Creek (T24). This waterbody was mistakenly identified as having the beneficial uses (6) warmwater marginal fishery and (8) limited contact recreation. However, this tributary has been designated as a (9) Fish and wildlife propagation, recreation, and stock watering waters; and (10) Irrigation waters (SD Administrative Code CHAPTER 74:51:03 USES ASSIGNED TO STREAMS). These two uses contain no DO standard.

EPA response: OK as long as this is clarified in the report and the samples show no impairment according to our assessment methodology.

- The percentage of data points used to determine if the WQS are being met or exceeded is shown in DENR's assessment methodology as >10 %. Typically this means that if the data have less than or equal to 10% exceeding the WQS, then it is considered meeting the standard. If more than 10% of the data exceed the WQS then it is considered not met. The common interpretation of "more than 10%" is anything greater than 10.00 (e.g., 10.01 or 10.1 if one significant figure is used). However, the Central Big Sioux report seems to use 11 as the percentage to determine whether the data is not meeting the WQS. This shifts the cut-off line from 10% to 11% and essentially exempts those sites with exceedance rates between 10% and 11% (see line defining meeting and not meeting in Figures 48 and 49 and the note in Figure 54 – "threshold is 11% to meet"). This approach is not consistent with SD DENR's assessment methodology. The line should be drawn at 10% and those sites with percent exceedance rates above the line should have TMDLs written to address the impairment. Similarly, lines drawn where less than 20 data points exist should be drawn at 25% not 26%.

SDDENR Response - On page 48 of the report it specifically states that listing criteria used by DENR was used in this report to determine support status, i.e. 10% or 25% depending on the number of samples. However, language has been added to the individual figures to reflect DENR's criteria for listing, i.e. greater than 10% (20 or more samples) or greater than 25% (5-19 samples). The data shown in the report is site specific not reflective of the entire segment.

EPA response: OK

- The load duration curves (LDCs) created for a few of the fecal coliform TMDLs (i.e., Six Mile Creek – Appendix WW; Beaver Creek - Appendix CCC; Pipestone Creek – Appendix EEE; Skunk Creek – Appendix

FFF) seem to have been created by combining two or more curves to form a single curve. For example, Pipestone Creek has two monitoring stations – T28 & T29. The LDC for T28 requires load reductions in every flow zone (81, 93, 76, 91, and 79 percent for high, moist, mid-range, dry and low respectively), and the LDC for T29 requires load reductions in all flow zones except dry (69, 83, 65, 0, and 76 percent for high, moist, mid-range, dry and low respectively). All percentages include a 10% MOS. However, when the curves are combined in the TMDL (Appendix EEE) the result is a LDC that requires an 89% reduction at high/moist flows and 87% reduction at dry/low flows, but no reductions at mid-range flows, whereas the individual curves require significant load reductions at mid-range flows. This may be a result of **averaging** the flows from both curves to create a single curve.

This approach does not appear to protect water quality from violations that have occurred at mid-range flows for Pipestone Creek. Also, by **averaging flows** from multiple stations to form a single curve, the new curve does not correspond to the flows at any of the individual stations (i.e., a theoretical curve has been created to derive the necessary TMDL loads). We do not recommend combining multiple curves in a segment into a single curve. Often, when there are multiple monitoring stations within a segment, the LDC for the monitoring station nearest the end of the segment is used to derive the TMDL loads (as was done for other TMDLs in the Central Big Sioux report), because it may best represent the reductions needed in that segment rather than the contributions from the upstream segment. We recommend using the curve from the monitoring station that is closest to the end of the segment to derive the loading capacity and revise the TMDLs for Six Mile Creek, Beaver Creek, Pipestone Creek and Skunk Creek.

SDDENR Response – Multiple curves were combined (not averaged) for the fecal coliform TMDLs because of the random distribution of the samples. There was no relationship between the flow and concentration for fecal coliform. Samples were clustered together resulting in flowzones with little or no data that could be used to calculate an existing load or reduction, i.e. Pipestone Creek Mid-range flows. The samples and flows between both sites were then used to calculate an existing load. If they were not combined this would not be possible. BMPs used to achieve the reductions at the high flow zone will have similar effects in the lower zones as well, i.e. Animal waste management systems and/or exclusionary fencing. Through implementation efforts at the high flowzone TMDLs will be met at all zones.

The problem is with the variability of the fecal coliform bacteria when combining or not combining data. The TMDL needs to be written for the entire reach/segment rather than for individual stations. Sampling was conducted on the same day on many sites so this method of combining data within a "reach" is more reflective and more protective of the entire segment. A TMDL should not be based on the individual sampling stations within a segment. **Currently we are using all the water quality data collected within a segment to determine impairment status as well.**

EPA response: Berry made the comment that we then need to clarify (in the document not the individual TMDLs) the process used to merge the data sets by adding a couple of paragraphs. He thinks he saw something in document that said the data was averaged and averaging is not acceptable for them. Will need to search document to determine if this wording exists and update it if it does.

Ruppel asked how far apart the stations were and EDWDD said they were about 15-18 stream miles apart. He said they will "think about this" (merging the data) to see if there will be a problem. He said "there may not be a problem" but he doesn't know and wants to think about it.

- It is not clear why the Central Big Sioux River report does not include a fecal coliform TMDL for Bachelor Creek. The previous draft Central Big Sioux River report included a fecal coliform TMDL that required an 85% reduction in loading during high/moist flows. Page 153 of the report says that "fecal coliform would need a reduction of 80 percent in the high flow range. The only explanation that we could find is in Table 62 (p. 209), which says that "A TMDL has previously been submitted during another assessment." However, we reviewed the Bachelor Creek assessment report (October 2000), and didn't find that a fecal coliform TMDL was written, and we have no record of a fecal coliform TMDL approval for this waterbody. The Bachelor Creek assessment report (Oct 2000) says that the water quality data didn't show "significant impairment" because WQS violations were only observed in 10% of the fecal coliform results. The current Central Big Sioux River report says that 38% of the data collected violated WQS. This indicates a declining trend in water quality. We recommend either including a fecal coliform TMDL for Bachelor Creek in the final Central Big Sioux River document, or an explanation that more data is needed before a TMDL can be developed.

SDDENR Response – Language was added to the report for Bachelor Creek showing the insufficient data need to develop a fecal coliform TMDL. This is based on the SDDENR listing methodology stating that with less than 10 samples 100% exceedance or meeting for support status. Additional data will be collected to determine if a TMDL is required.

EPA response: Berry said we need to change the language within the report to explain we had insufficient info and it needs to be more specific.

- The Spring Creek fecal coliform TMDL (Appendix XX) uses the median concentration across all flow zones to derive the load reduction needed and the existing load estimate. As is mentioned in the comment below, these reductions will mostly be used to guide post-TMDL implementation. However, this approach is not consistent with similar stream segments in this report. The justification for using this approach is because of the limited sample data for this site (Appendix XX, p. 8). The TMDLs for Jack Moore Creek, Flandreau Creek and North Deer Creek were also developed with limited sample data, however, they combined the high and moist zones and the dry and low zones to result in 3 zones rather than 1, as was done for Spring Creek. We recommend revising the Spring Creek TMDL following the procedure used for Jack Moore Creek, Flandreau Creek and North Deer Creek.

SDDENR Response – Changes have been made to the fecal coliform TMDL. Additional flowzones were used to calculate the TMDL.

EPA response: Berry said they will take a "look" at this and said the excuse of limited data needs to be justified further because other sites had limited data too. EPA will be talking with Cleland about justifying (standardizing) when you should use 3 vs. 5 flow zones but they won't push that with this TMDL. Berry talked a little more and said 5 flow zones is usually standard. He wants us to explain in the larger body of the text under what situation would it be appropriate for us to use 3 flow zones but don't justify it just by saying there is limited data.

- The Flow Duration Interval section (pp. 45 – 46) and the individual TMDLs mention that the existing loads and the reductions goals are based on the median concentration of the fecal coliform bacteria and total suspended solids samples from each flow zone. While we recognize that use of the median concentration data is largely used to as a guide for post-TMDL implementation, we are concerned that each TMDL uses the calculated percent reductions as the TMDL "goal." The amount of load reduction necessary to achieve the water quality standards is likely higher than the values derived using the median concentrations. The LDC guidance document (See: "An Approach for Using Load Duration Curves in the Development of TMDLs," EPA 841-B-07-006, August 2007 - http://www.epa.gov/owow/tmdl/duration_curve_guide_aug2007.pdf), and training modules developed by Bruce Cleland mention using the 90th percentile values of the data within each flow zone. Using the 90th percentile values ensures that no more than 10 percent of the data will exceed the applicable water quality standard. This approach is consistent with the assessment methodologies of many states which allow up to a 10 percent exceedance of the WQS before listing the water body as impaired. We recommend either: 1) removing the percent reductions from the TMDLs entirely (Appendices SS – FFF) – specifically remove them as the "Goal" for each TMDL and remove the reduction tables within each TMDL; 2) use the 90th percentile values to be consistent with DENR's assessment methodology and the examples in the LDC guidance; or 3) move the percent reduction tables and percent reduction goals to the Implementation section of each TMDL. Also, include a statement in the Implementation section that the reductions derived from the median concentrations will be used as a starting point to begin implementation, but that additional controls may be needed in order to achieve the applicable water quality standards and meet the loads specified in the TMDL.

SDDENR Response – The number of samples and time invested in this TMDL do not allow us to change the TMDL. However, future TMDL development with load duration curves will use the 90%tile where applicable. There should be a minimum requirement for numbers of samples within each flowzone before the 90%tile or any percentile is used to calculate the existing load. Guidance should reflect this regarding the minimum number of samples needed for each flowzone. No specific rule exists that states the requirement for the 90th percentile. Also, Bruce Cleland was consulted several times in the development of these TMDLs. The document referred to in your comments also states that the median can be used along with 90th percentile.

EPA response: Berry said we don't have to go back and use 90% tile but we do need to go back in and change the TMDL goal. Right now the TMDL goal doesn't match our listing methodology or our WQS. He suggested we move the TMDL goal language into the implementation section and change the goal to the water quality standard (option 3 identified above). The goal now states a percent reduction based on the median value within each flowzone. This premise allows violations of the daily max standard which is why the TMDL goal needs to bc changed to the daily max standard. Need to get away from percent reductions.

SDDENR changed the TMDLs to reflect option 3, i.e. moving the percent reductions to implementation section.

12 TMDLs to be Submitted for Final Approval:

Appendix TT.	I-29 to Near Dell Rapids (TSS)
Appendix UU.	Near Dell Rapids to Below Baltic (Fecal Coliform Bacteria)
Appendix VV.	North Deer Creek (Fecal Coliform Bacteria)
Appendix XX.	Spring Creek (Fecal Coliform Bacteria)
Appendix YY.	Flandreau Creek (Fecal Coliform Bacteria)
Appendix ZZ.	Jack Moore Creek (Fecal Coliform Bacteria)
Appendix AAA.	Split Rock Creek (TSS)
Appendix BBB.	Split Rock Creek (Fecal Coliform Bacteria)
Appendix CCC.	Beaver Creek (TSS)
Appendix DDD.	Beaver Creek (Fecal Coliform Bacteria)
Appendix EEE.	Pipestone Creek (Fecal Coliform Bacteria)
Appendix FFF.	Skunk Creek (Fecal Coliform Bacteria)

2 TMDLs to be withheld at this time along with Bachelor Creek:

Appendix SS.	Brookings to I-29 (TSS) for MS4 Reasons
Appendix WW.	Six Mile Creek (Fecal Coliform Bacteria) for MS4 Reasons
No Appendix.	Bachelor Creek (Fecal Coliform) not enough data, and/or old data. Will be reviewed this year.